

4.5.4 Regional Ozone Concentrations

Maximum ozone concentrations observed at several locations in the area are given in Table 4.5.4. With a slight reduction in 850mb temperature to 20°C, maximum surface ozone concentrations were somewhat below those observed on September 26. Piru, South Mt., Thousand Oaks and Moorpark were the only locations where the maximum hourly concentration exceeded the state standard. Average background ozone concentration, as measured during the aircraft spirals, was 5 pphm which is the same as found on September 26.

Time histories of the hourly ozone values for several stations are shown in Figure 4.5.2. Simi and Ojai reached their peak values about 13 PST. The main peak at Piru occurred slightly later. The hourly concentration plot for Piru suggests an early peak in agreement with Simi and Ojai and a later, more important peak which was associated with the marine layer intrusion, 2-3 hours after the peak temperature was reached. An aircraft sounding (Section 4.5.5) at Piru at 1458 PDT shows two ozone layers with a shallow marine layer contributing the peak ozone contributions beginning at 14 PST.

In contrast to the previous test days, the Ventura maximum ozone concentration occurred at 13-14 PST with a rather slow decrease until 19 PST. As noted in Table 4.5.4, Platform Grace had two identical peaks of 8 pphm each, at 11 and 15 PST. Concentrations associated with the second peak may have contributed to the slow decrease in ozone observed at Ventura in the late afternoon. The Pt. Hueneme, ozone concentrations, for example, peaked at 15-16 PST, similar to the previous tests.

All ozone stations shown in Fig. 4.5.2 show the usual indications of peak values from 12-13 PST which could be associated with sources in the coastal region. All stations except Simi, however, were strongly influenced by a late afternoon surge of ozone arriving from the offshore area.

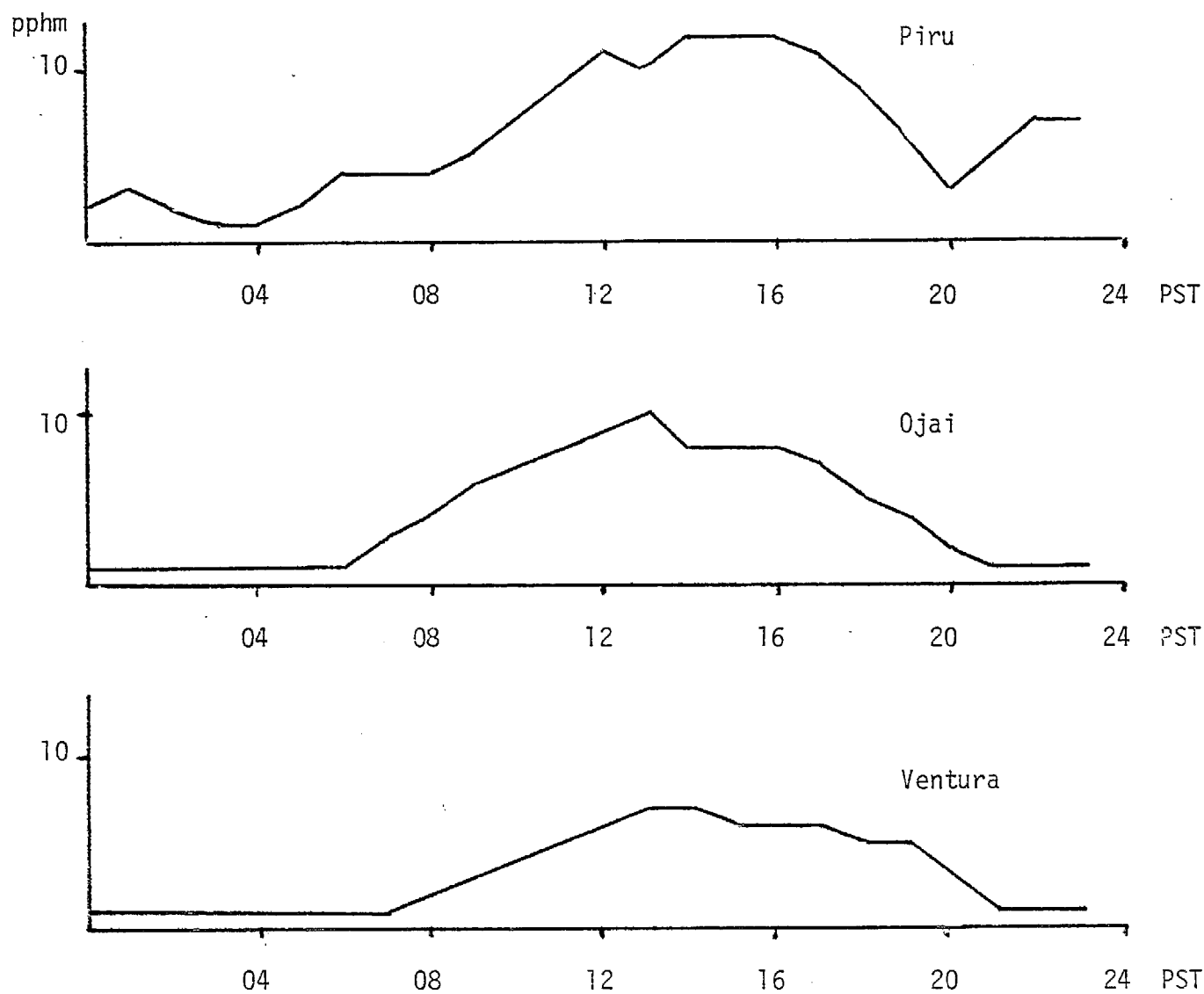


Fig. 4.5.2a HOURLY OZONE CONCENTRATIONS - September 28, 1980

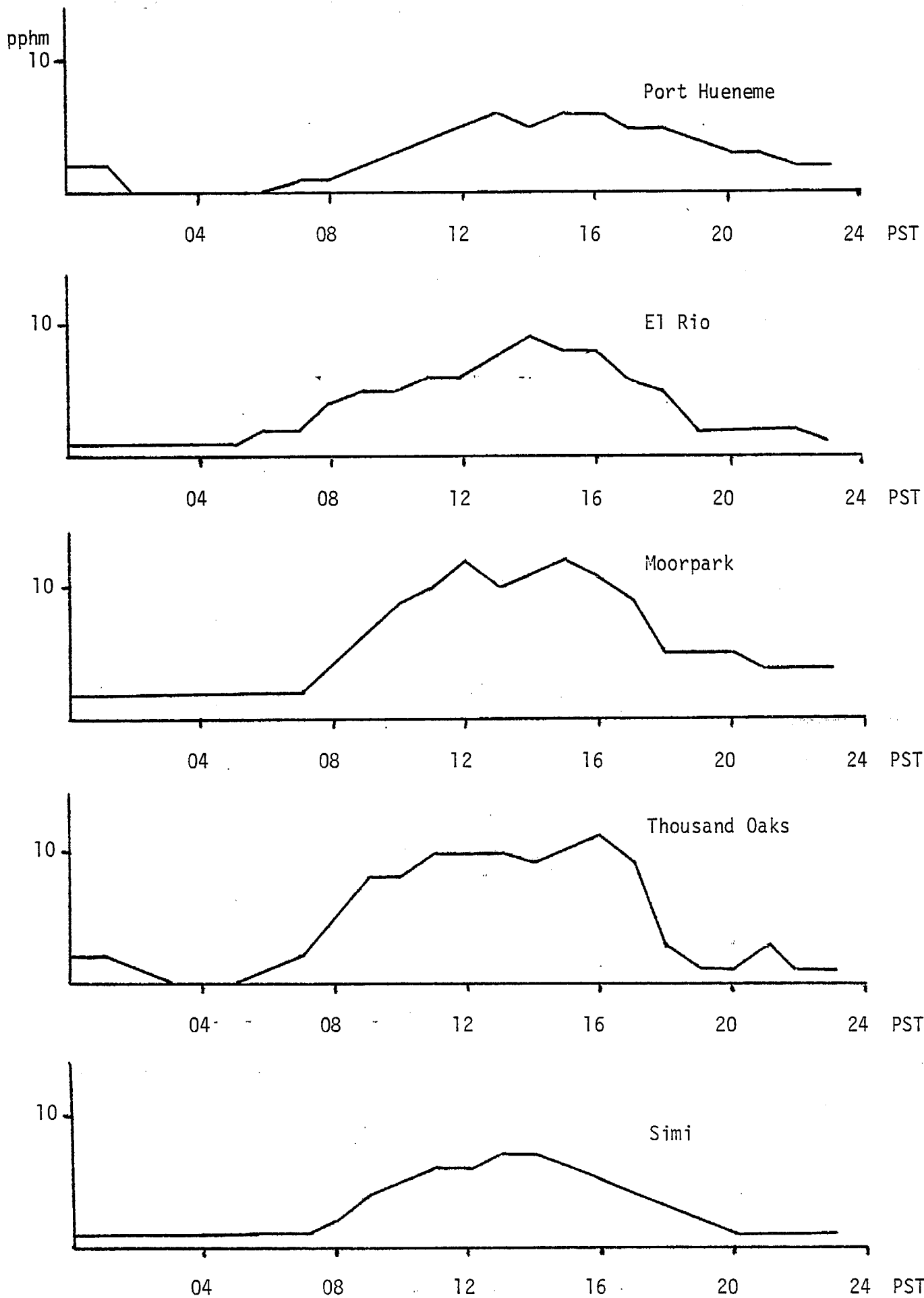


Fig. 4.5.2b HOURLY OZONE CONCENTRATIONS - September 28, 1980

Table 4.5.4

Regional Maximum Ozone Concentrations (pphm)

September 28, 1980

Location	Max O ₃	Time of Max (PST)	Wind Direction at Time of Max	Time of Max Temp (PST)
Pt. Conception	4	00-04,06-14,16-22	300-030°	12
Goleta	7	13-14	150	14
Platform Hondo	5	12-16	117	--
Ojai	10	13	295	12
Piru	12	14-16	240	12-13
Simi Valley	7	13-14	280	14
South Mt.	12	17	340	11
Thousand Oaks	11	16	320	11
Moorpark	12	12-15	M	M
El Rio	9	14	M	M
Ventura	7	13-14	225	09-11
Pt. Hueneme	6	15-16	270*	13-16*
Platform Grace	8	11-15	169,240	17
Background	5			

*Pt. Mugu

4.5.5 Aircraft Sampling

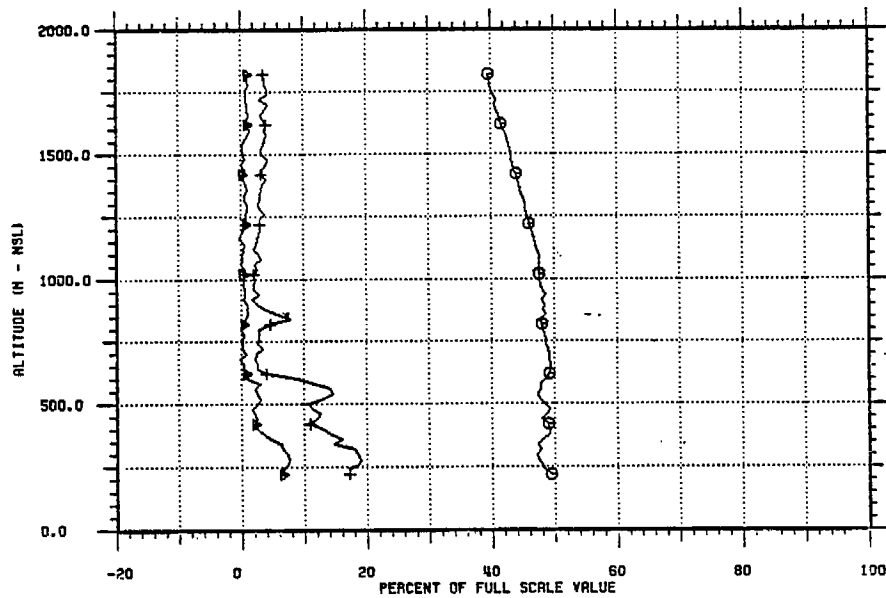
The air quality aircraft sampled on September 28 along the coast line from Santa Barbara to Oxnard, in the interior valleys (Ojai, Piru and Simi) and over the water as far as Platform Grace.

The first sounding on September 28 was made between Lake Casitas and Ojai at 1336 PDT (Figure 4.5.3). The vertical temperature and pollutant structures showed evidence of mixing to 600 m-msl although the well-mixed layer was shallow and only extended to 350 m-msl. Ozone concentrations were about 11 pphm throughout the layer to 700 m-msl, decreasing to 5 pphm aloft. Winds in the layer to 700 m-msl were from the west-southwest but shifted abruptly to southeast above 700 m.

A horizontal traverse was then flown from northeast of Ojai to the coastline (Figure 4.5.4). It can be seen that b_{scat} , NO_x and SO_2 peaked in the vicinity of Ojai while ozone also showed a slight peak. This tends to suggest the influence of local sources in the Ojai Valley. The ozone levels along the traverse to the coast average 10 pphm which was also the maximum recorded at Ojai for the day.

SANBOX STUDY
SPIRAL AT POINT 1

TAPE/PASS: 184/2 DATE: 9 /28/80
TIME: 1336 TO 1346 (PDT)



821201.0
16:20:17

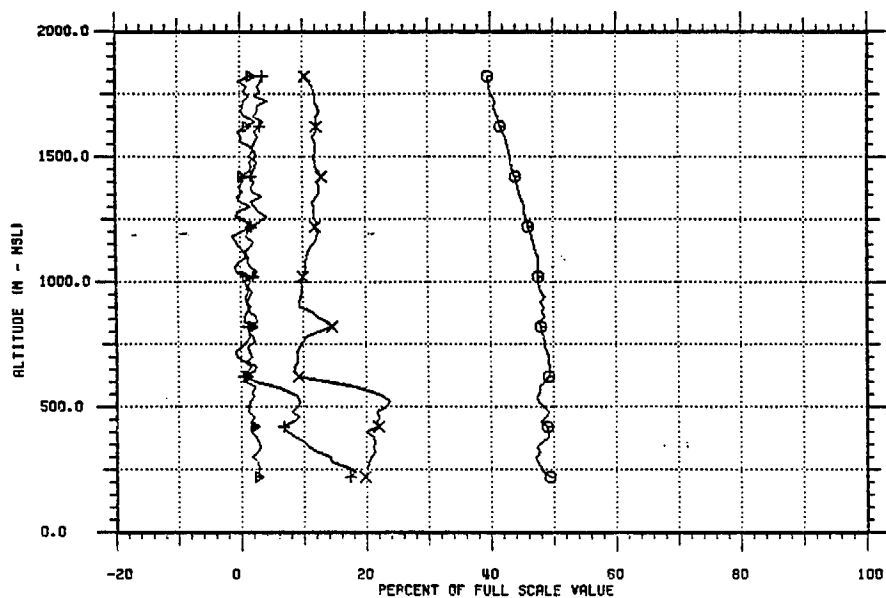
AIRCRAFT SOUNDING NEAR OJAI

(1336 PDT)

September 28, 1980

SANBOX STUDY
SPIRAL AT POINT 1

TAPE/PASS: 184/2 DATE: 9 /28/80
TIME: 1336 TO 1346 (PDT)



821201.0
16:20:17

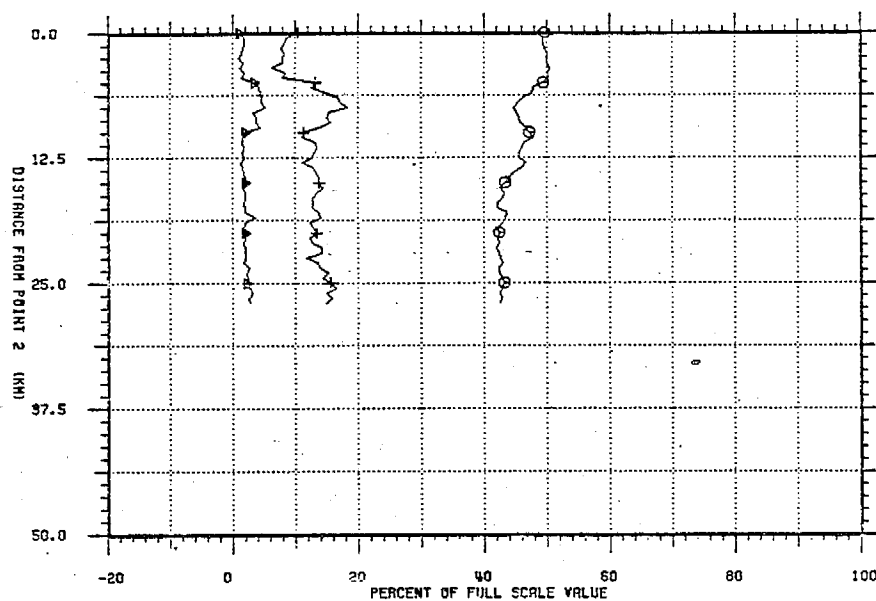
Fig. 4.5.3

SANBOX STUDY

TRAVERSE FROM POINT 2 TO POINT 3 (457 M MSL)

TAPE/PASS: 184/3 DATE: 9 /28/80

TIME: 1350 TO 1358 (PDT)



FULL SCALE VALUE

○ TEMP	50.	DEG. C
▴ SO ₂	100.	PPB
+ B _{BENT}	1000.	10 ⁻⁶ M ⁻¹

821201.0
16:20:17

AIRCRAFT TRAVERSE - OJAI TO COAST

(1350 PDT)

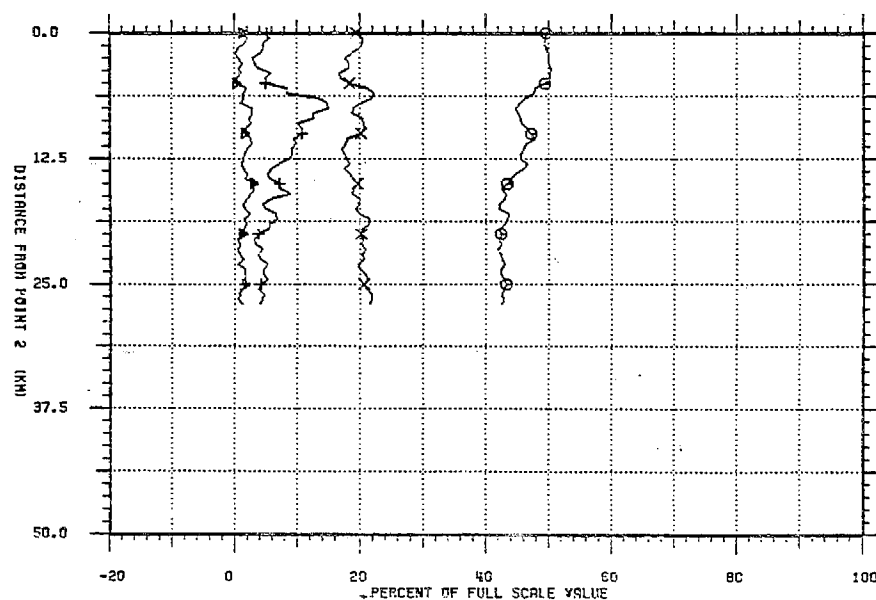
September 28, 1980

SANBOX STUDY

TRAVERSE FROM POINT 2 TO POINT 3 (457 M MSL)

TAPE/PASS: 184/3 DATE: 9 /28/80

TIME: 1350 TO 1358 (PDT)



FULL SCALE VALUE

○ TEMP	50.	DEG. C
▴ NO	200.	PPB
+ NO _x	200.	PPB
× O ₃	500.	PPB

821201.0
16:20:17

Fig. 4.5.4

The next spiral was carried out in the vicinity of Platform Grace at 1410 PDT (Figure 4.5.5). The temperature structure shows a very shallow mixed layer (about 100 m deep) with an extensive inversion to a level of 100 m-msl. The shallow surface layer was characterized by moderate turbulence while the values within the inversion layer were extremely small. There is evidence, however, in the pollutant parameters of a deeper layer of pollutants extending to 500 m-msl with a sharp top at that level. The lack of turbulence at the levels above 100 m requires that the material be advected into the area from upwind sources or that horizontal roll vortices be present in the offshore area. Upper winds observed at Ventura at the time indicated westerly winds to a level of 662 m-msl, with easterly winds aloft. Ozone levels peaked at 17 pphm near 400 m-msl but were reduced to about 6 pphm in the surface layer. Peak ozone recorded on Platform Grace on September 28 was 8 pphm.

A horizontal traverse was then flown at an altitude of 457 m-msl from Platform Grace to Ventura to Piru beginning at 1436 PDT (Figure 4.5.6). The approximate position of the coast line is shown in the figure. The NO_x concentrations were low over the water but exhibited two peaks inland, probably associated with Santa Paula and Fillmore/Piru. bscat values were similar but with relatively higher values over the water. Ozone concentrations, however, ranged from 12-17 pphm over the water to 10-15 pphm inland. The portion of the route from Santa Paula to near Piru showed ozone values of 12-15 pphm. The peak surface value observed at Piru was 12 pphm on September 28. The highest value observed at any location in the Santa Barbara/Ventura area was 12 pphm at Piru and Moorpark although concentrations of 17 pphm were observed aloft in the offshore area.

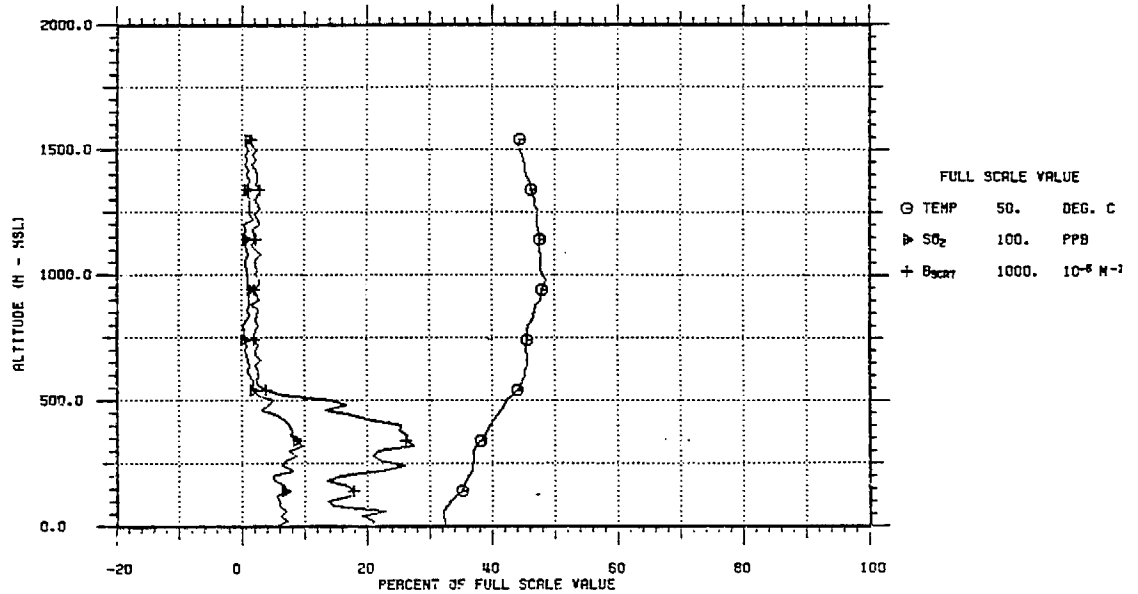
A sounding was made at 1458 PDT at Piru (Figure 4.5.7). The temperature structure indicated a well-mixed layer to 350 m-msl, topped by a stable layer to 1000 m-msl. The pollutant structure also showed the presence of two layers. Although no upper wind observations were made at Piru, the winds at Simi were west to southwest in the layer from the surface to 600 m-msl with easterly winds above that level. Ozone concentrations were about 13 pphm near the bottom of the sounding but exhibited a peak of 17 pphm at 750-850 m-msl. According to the available winds the ozone in the upper layer probably came from the San Fernando Valley.

The next sounding occurred at Santa Paula Airport at 1517 PDT (Figure 4.5.8). The temperature structure showed a mixed layer from the surface to 250 m-msl, capped with an isothermal layer to 1000 m-msl. Extensive layering was observed in the pollutant soundings at 550, 900 and 1300 m-msl. These layers were apparent in all pollutant parameters except NO . Peak ozone was 14, 14 and 11 pphm in the three layers. Available upper wind observations suggest that these three layers occurred in the air moving from the east and southeast.

SANBOX STUDY

SPIRAL AT POINT 6

TAPE/PASS: 184/5 DATE: 9 /28/80
TIME: 1410 TO 1422 (PDT)



821201.0
16:20:17

AIRCRAFT SOUNDING AT PLATFORM GRACE

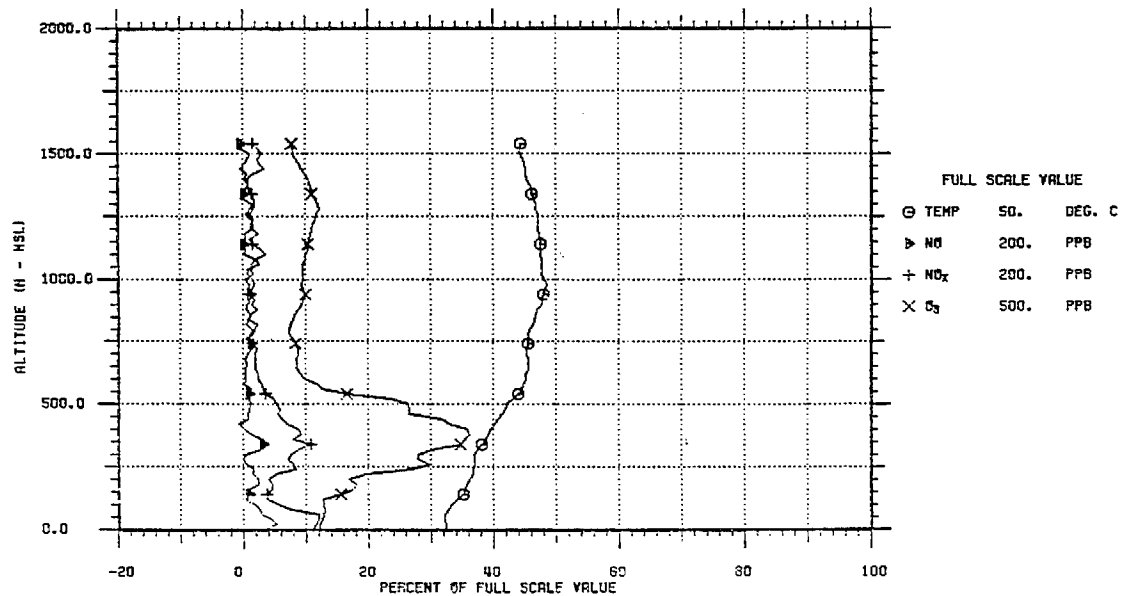
(1410 PDT)

September 28, 1980

SANBOX STUDY

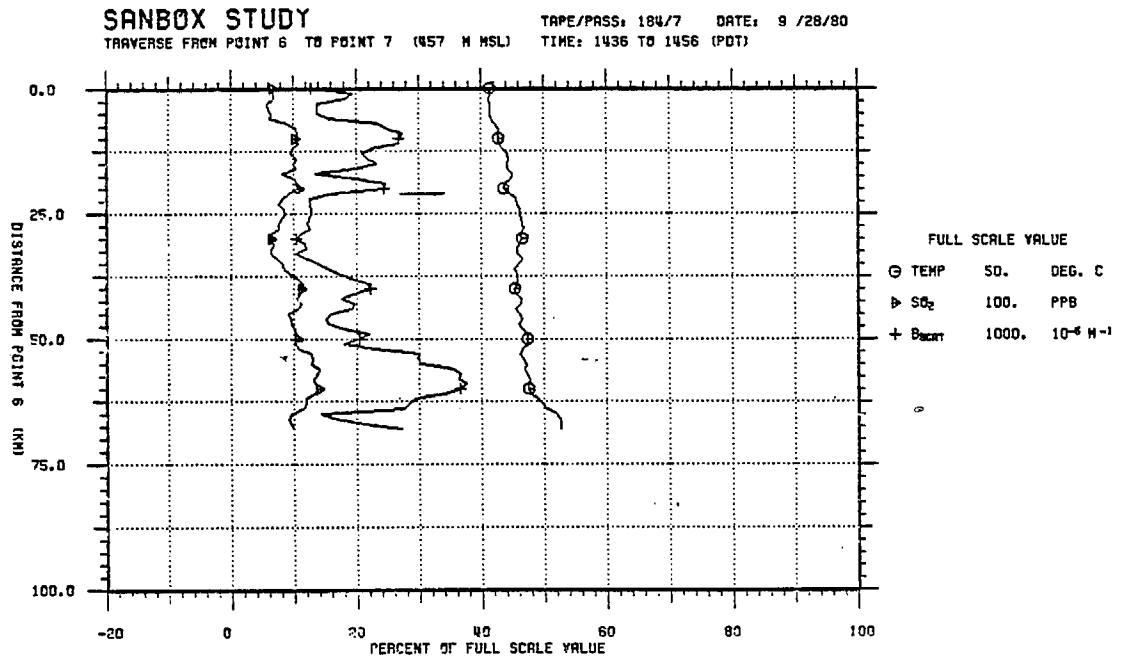
SPIRAL AT POINT 6

TAPE/PASS: 184/5 DATE: 9 /28/80
TIME: 1410 TO 1422 (PDT)



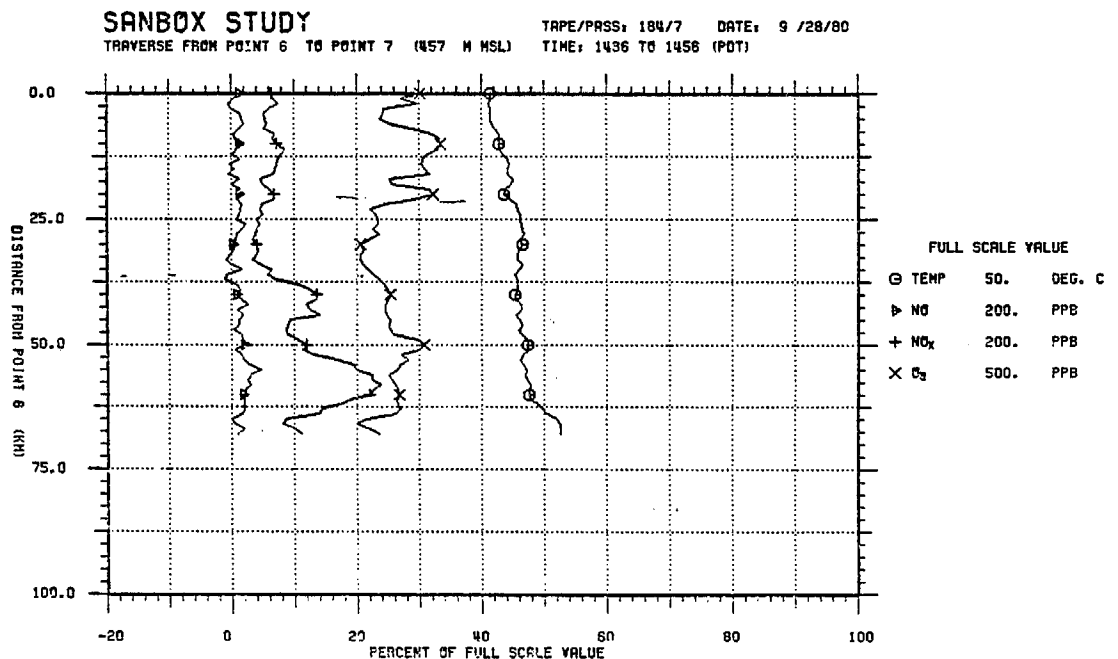
821201.0
16:20:17

Fig. 4.5.5



621201.0
 16:23:17

AIRCRAFT TRAVERSE - GRACE TO PIRU
 (1436 PDT)
 September 28, 1980

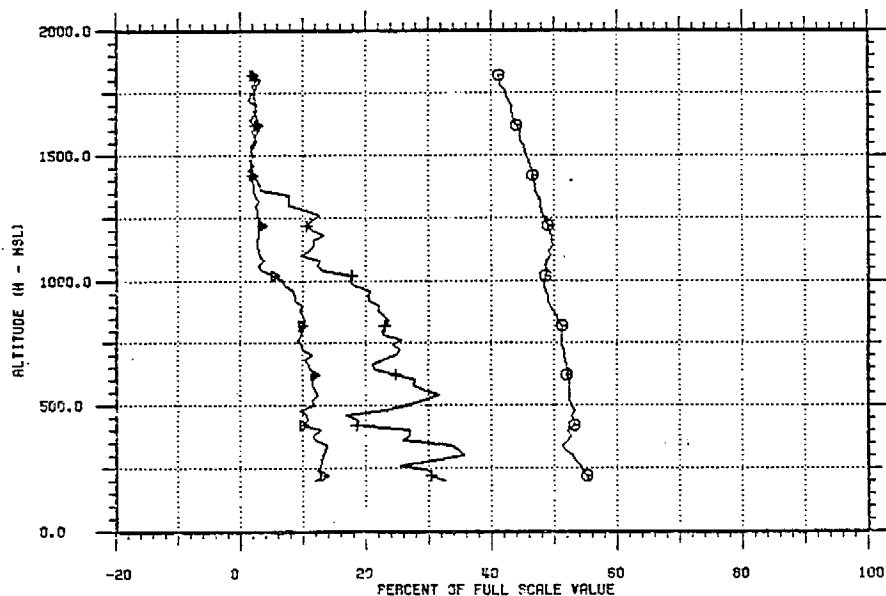


621201.0
 16:20:17

Fig. 4.5.6

SANBOX STUDY
SPIRAL AT POINT 7

TAPE/PASS: 184/8 DATE: 9 /28/80
TIME: 1458 TO 1510 (PDT)



921201.0
13:20:17

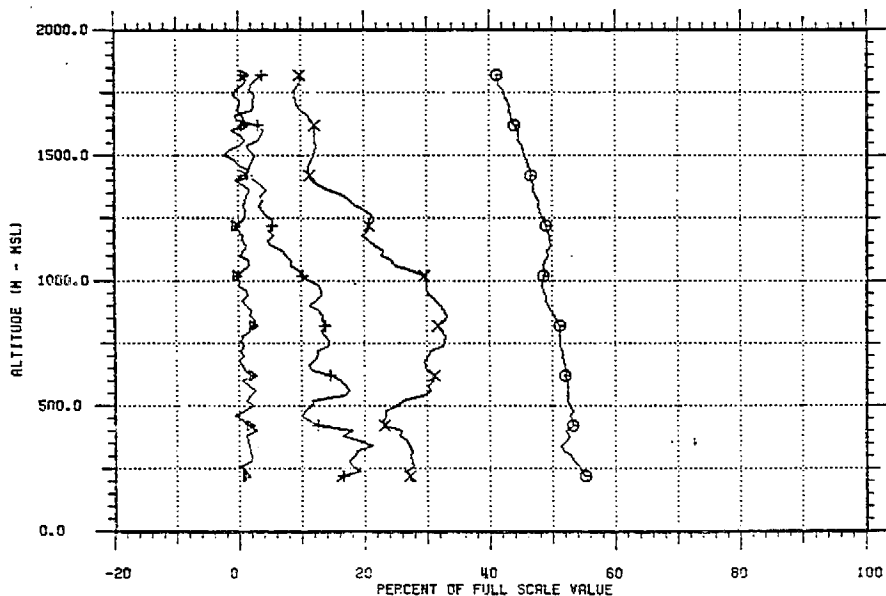
AIRCRAFT SOUNDING AT PIRU

(1458 PDT)

September 28, 1980

SANBOX STUDY
SPIRAL AT POINT 7

TAPE/PASS: 184/8 DATE: 9 /28/80
TIME: 1458 TO 1510 (PDT)

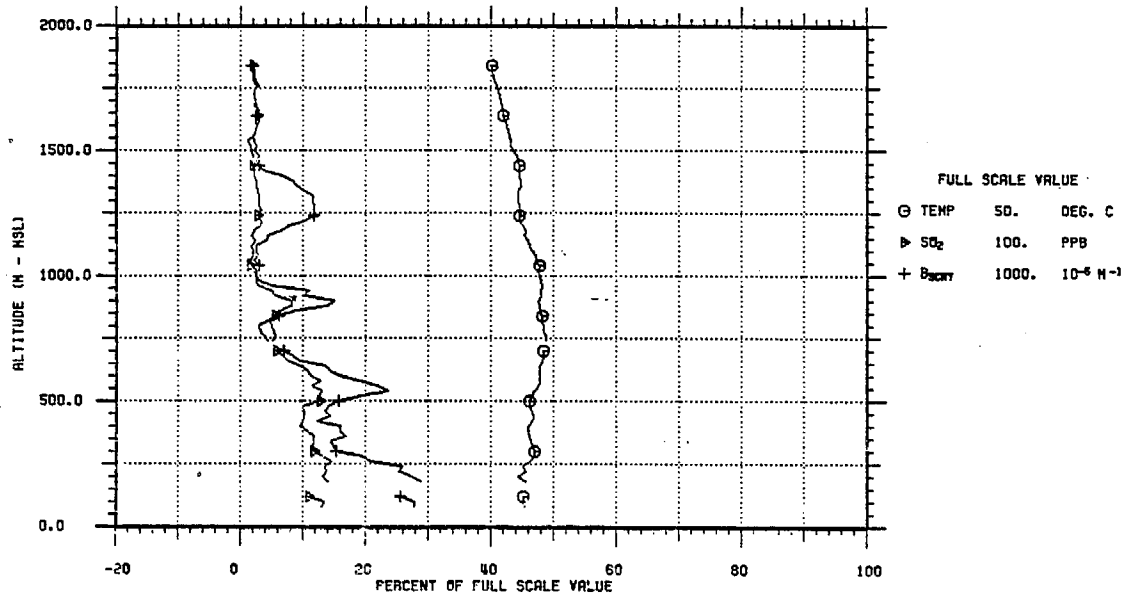


921201.0
16:20:17

Fig. 4.5.7

SANBOX STUDY
SPIRAL AT POINT 8

TAPE/PASS: 184/9 DATE: 9 /28/80
TIME: 1517 TO 1527 (PDT)



821201.0
16:20:17

AIRCRAFT SOUNDING AT SANTA PAULA
(1517 PDT)
September 28, 1980

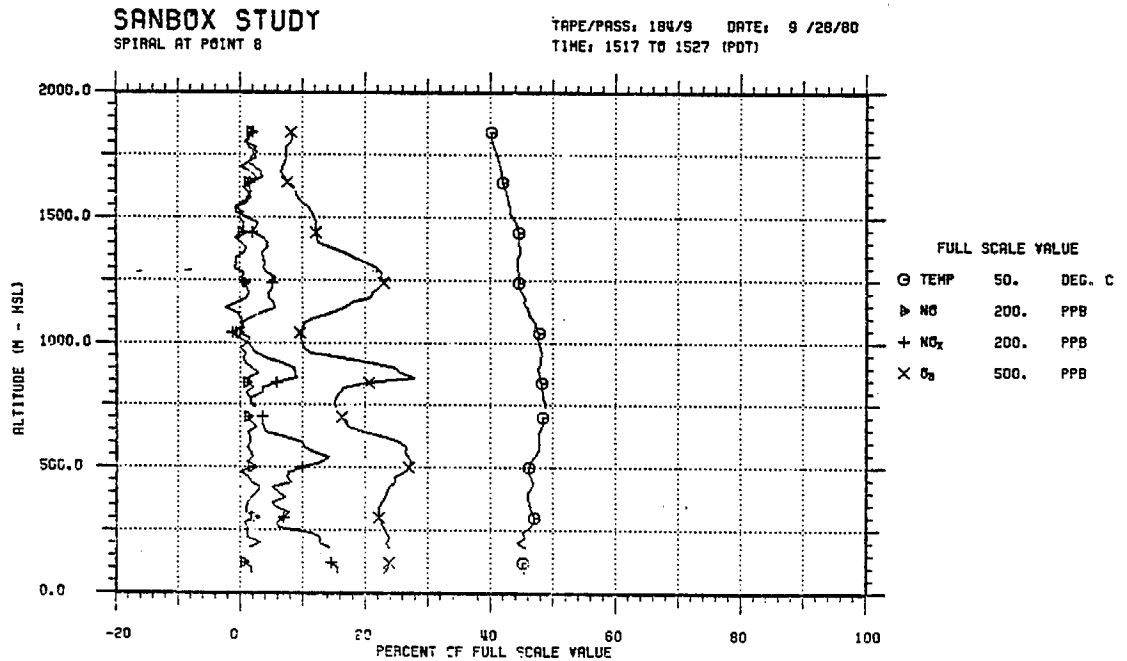


Fig. 4.5.8

821201.0
16:20:17

The next spiral was made at Santa Susana Airport at 1556 PDT (Figure 4.5.9). There was a temperature inversion at 550 m-msl with an isothermal structure at higher levels. Ozone values in the low layers were about 12 pphm, somewhat higher than the peak, observed, surface concentration of 7 pphm at Simi. Aloft, however, an extensive ozone layer with peak value of 23 pphm was observed, centered between 850 and 1100 m-msl. The layer was also characterized by high values of NO_x and b_{scat} . The upper winds measured at Simi indicate that the layer above 800 m-msl was a part of the flow from the San Fernando Valley.

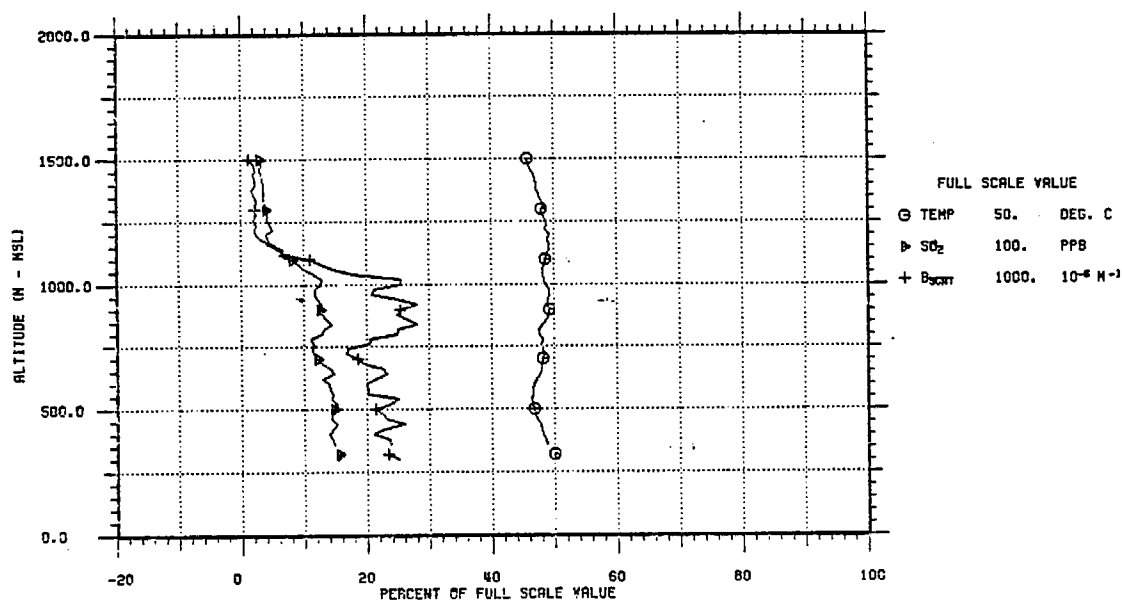
The final spiral was made at 1610 PDT (Fig. 4.5.10) at the western edge of the San Fernando Valley about 20 km east of Thousand Oaks. There was a mixed layer to 1000 m-msl topped with a slight temperature inversion. Ozone, NO_x and b_{scat} all peaked at the base of the inversion. Highest ozone value observed was 22 pphm from 950 to 1100 m-msl. This was clearly the same layer observed at Santa Susana (Figure 4.5.9) and earlier with somewhat lower concentrations at Piru.

A subsequent traverse from the San Fernando Valley to Oxnard at 762 m-msl indicated that the western edge of the ozone layer was not as far west as Thousand Oaks by 1630 PDT.

SANBOX STUDY

SPIRAL AT POINT 10

TAPE/PASS: 184/12 DATE: 9 /28/80
TIME: 1556 TO 1605 (PDT)



221201.0
15:20:17

AIRCRAFT SOUNDING AT SANTA SUSANA

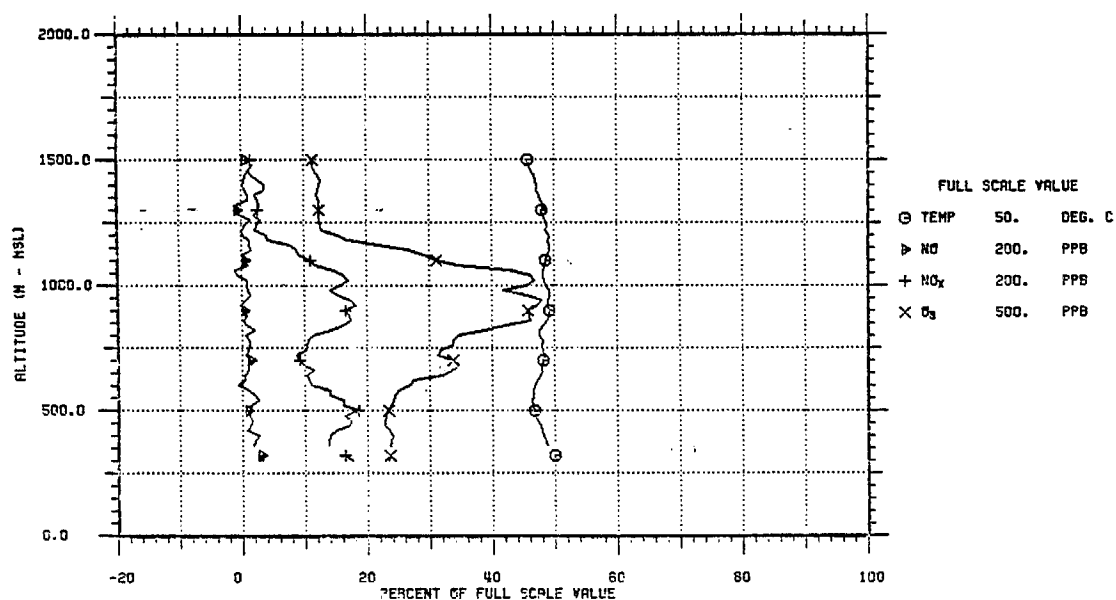
(1556 PDT)

September 28, 1980

SANBOX STUDY

SPIRAL AT POINT 10

TAPE/PASS: 184/12 DATE: 9 /28/80
TIME: 1556 TO 1605 (PDT)

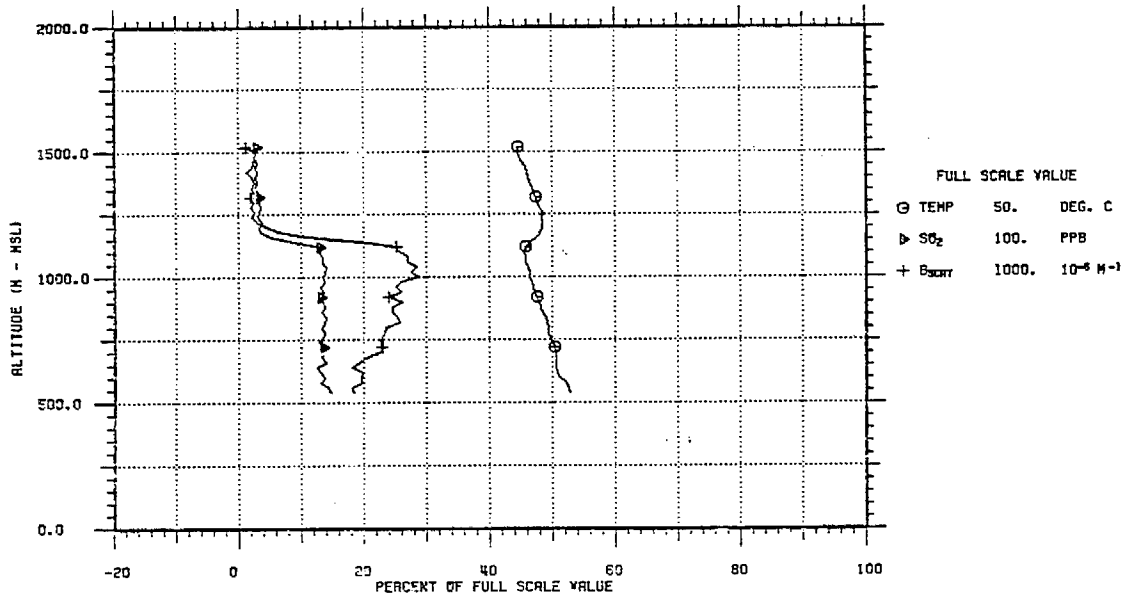


221201.0
16:20:17

Fig. 4.5.9

SANBOX STUDY
SPIRAL AT POINT 11

TAPE/PASS: 184/13 DATE: 9 /28/80
TIME: 1610 TO 1617 (PDT)

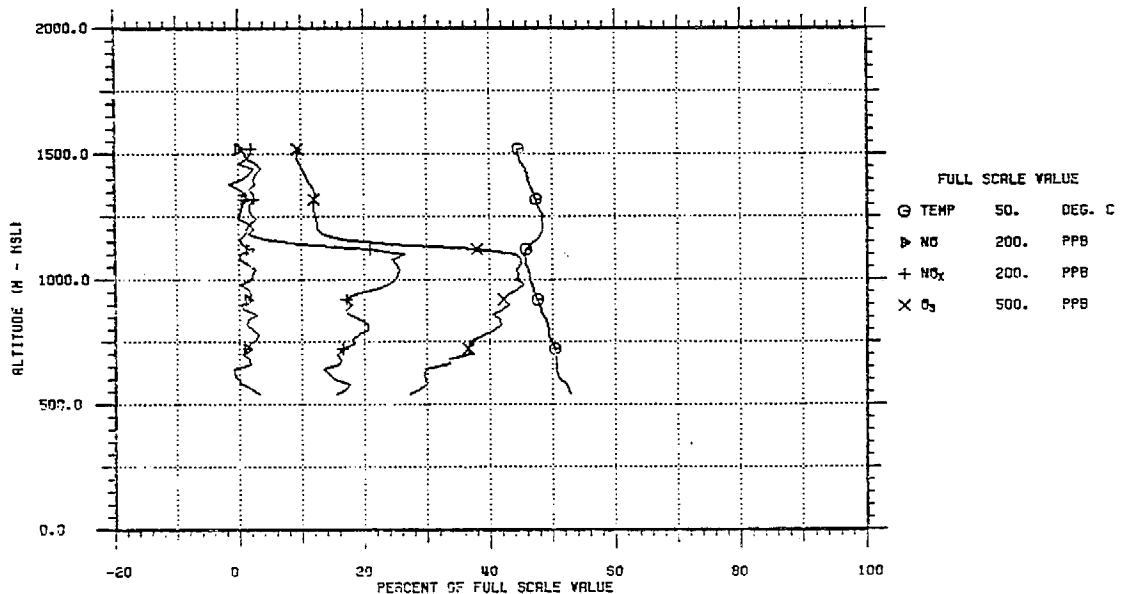


821201.0
16:20:17

AIRCRAFT SOUNDING - W SAN FERNANDO VALLEY
(1610 PDT)
September 28, 1980

SANBOX STUDY
SPIRAL AT POINT 11

TAPE/PASS: 164/13 DATE: 9 /28/80
TIME: 1610 TO 1617 (PDT)



821201.0
16:20:17

Fig. 4.5.10

4.5.6 Tracer Results - Test 4

Release Location: 4 mi West of Ventura

Date: September 28, 1980

Time: 1240-1900 PDT

Release Rate: 6.18 g SF₆ per sec

The release on September 28 was a joint release with the BLM program. The release was made from the R/V Acania.

Surface winds during the release are given in Table 4.5.5 for the Acania and for Surfer's Point at Ventura which was the closest available observation on land.

Table 4.5.5

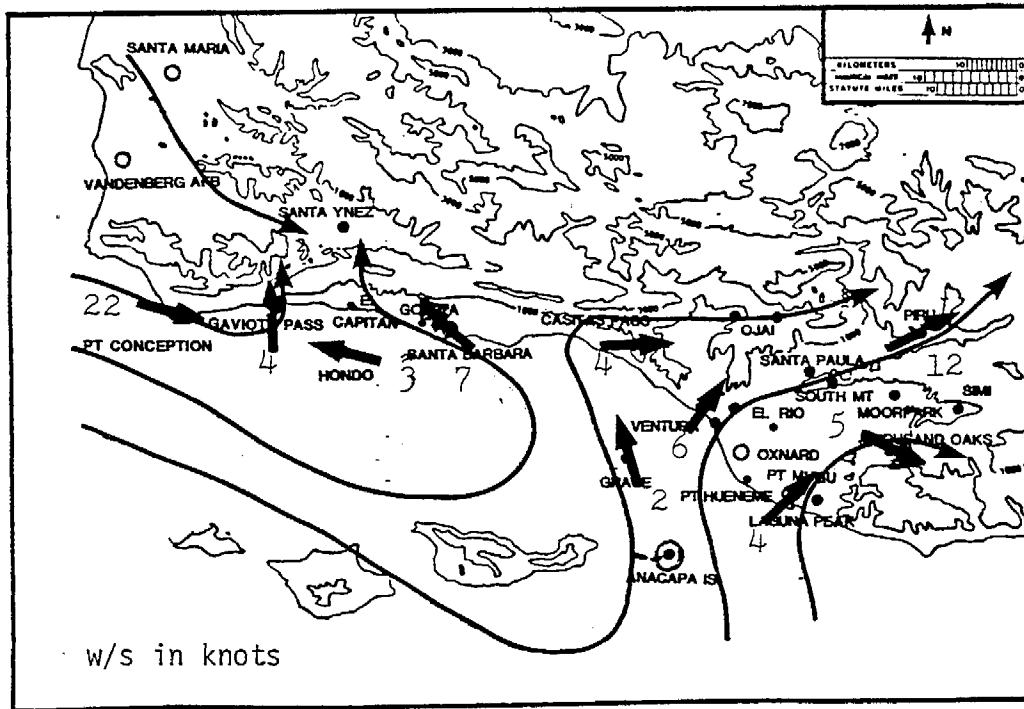
Surface Winds September 28, 1980

Time	Acania		Surfer's Point	
	w/d	w/s	w/d	w/s
13 PDT	231°	2.0 m/s	220°	2.9 m/s
14	247	2.9	225	3.3
15	257	3.0	225	3.3
16	253	3.4	235	3.2
17	---	---	235	3.3
18	260	3.5	210	1.7
19	257	2.3	210	0.7

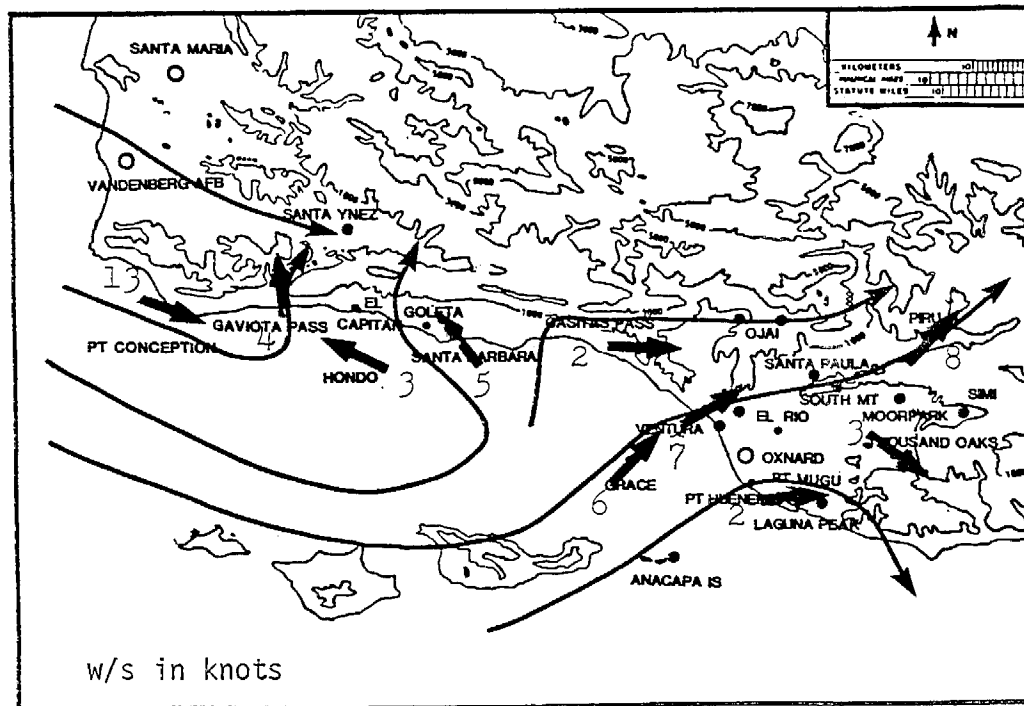
Surface winds during the release were southwesterly at both locations with similar velocities until late in the period when the seabreeze flow along the coast decreased substantially. The winds in the table indicate that the release was made into the seabreeze flow which extended offshore as far as the position of the Acania (4 mi west of Ventura).

Streamline charts for September 28 are shown in Figures 4.5.11 and 4.5.12. An onshore flow had developed along the Ventura County coast line by 12 PST, continuing through 16 PST. By 20 PST offshore flow had commenced in the northern part of the County with onshore flow continuing south of Ventura. Weak, offshore flow also prevailed at 24 PST.

Tracer trajectories for September 28 are shown in Figure 4.5.13 together with times of observed maximum concentrations at various locations. The principal tracer route was toward Piru with a secondary branch following the Ojai Valley. A portion of the material following the Piru route apparently did not escape in the upslope flow and returned to the coastal plains during the night.

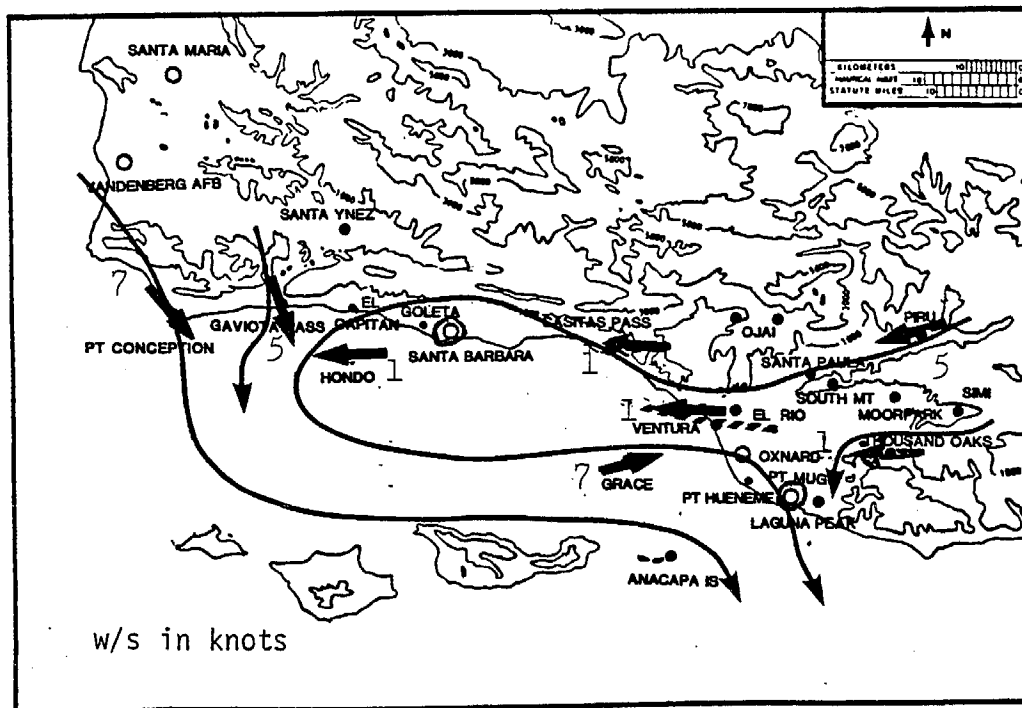


12 PST

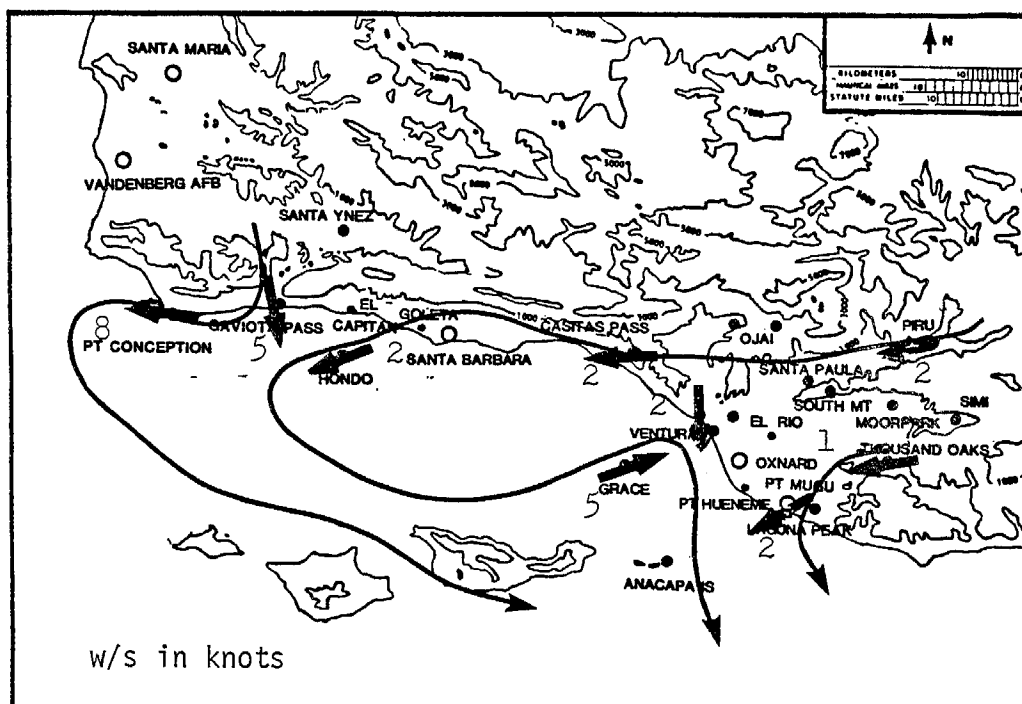


16 PST

Fig. 4.5.11 STREAMLINE CHARTS - September 28, 1980

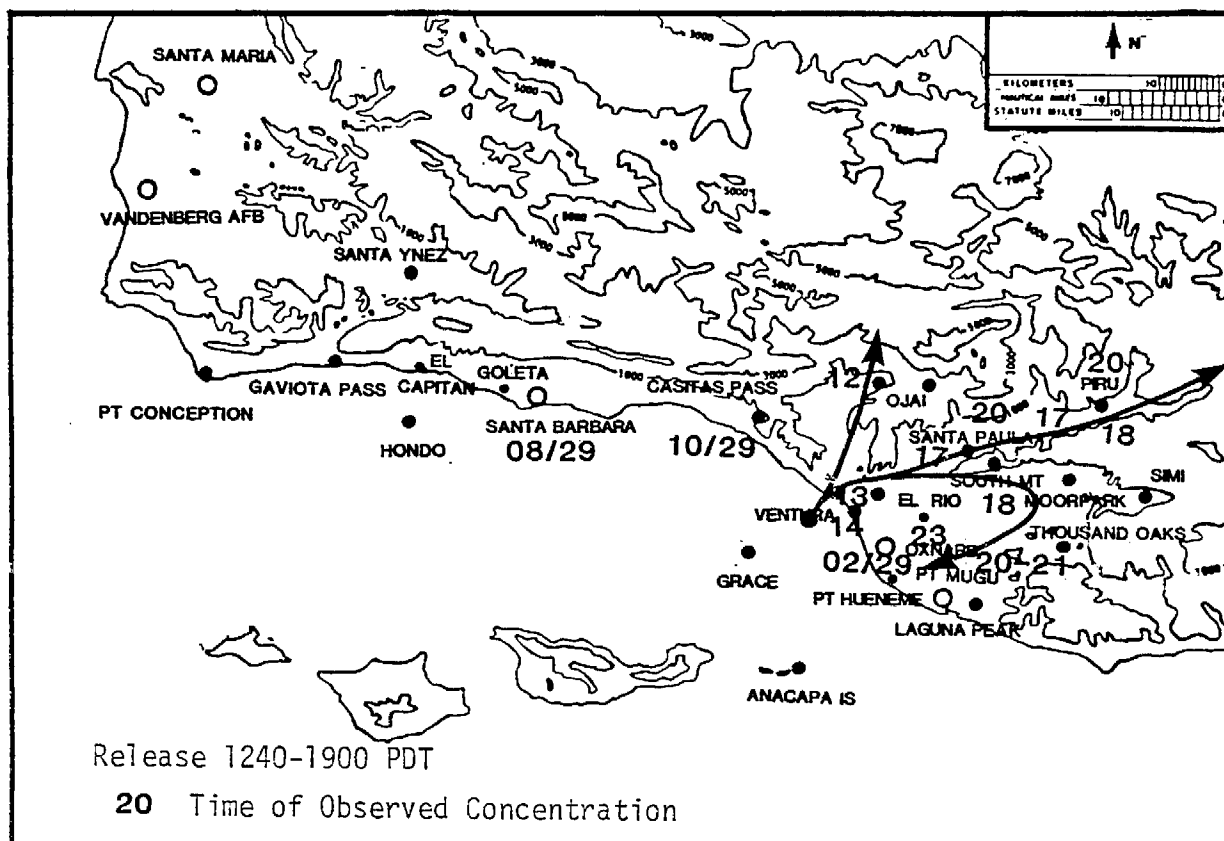


20 PST



24 PST

Fig. 4.5.12 STREAMLINE CHARTS - September 28, 1980



ESTIMATED TRACER TRAJECTORIES - September 28, 1980

Fig. 4.5.13

Figure 4.5.14 give the hourly ozone and SF₆ histories at Ojai and Piru on September 28. Peak ozone concentrations occurred at Piru at 14-16 PST and 13 PST at Ojai. A strong SF₆ peak was observed at Piru at 19 PST but no major tracer concentrations were found at Ojai. As indicated by the tracer concentrations at Ventura the peak of the tracer material passed the coast line between 14-21 PDT. Based on the peak ozone period observed at Piru, the air parcels containing this ozone probably left the coastal area prior to the arrival of the SF₆ from offshore. In view of the long release period and the short downwind distances involved, it is not possible to get a reliable estimate of travel velocity from the release point to inland locations.

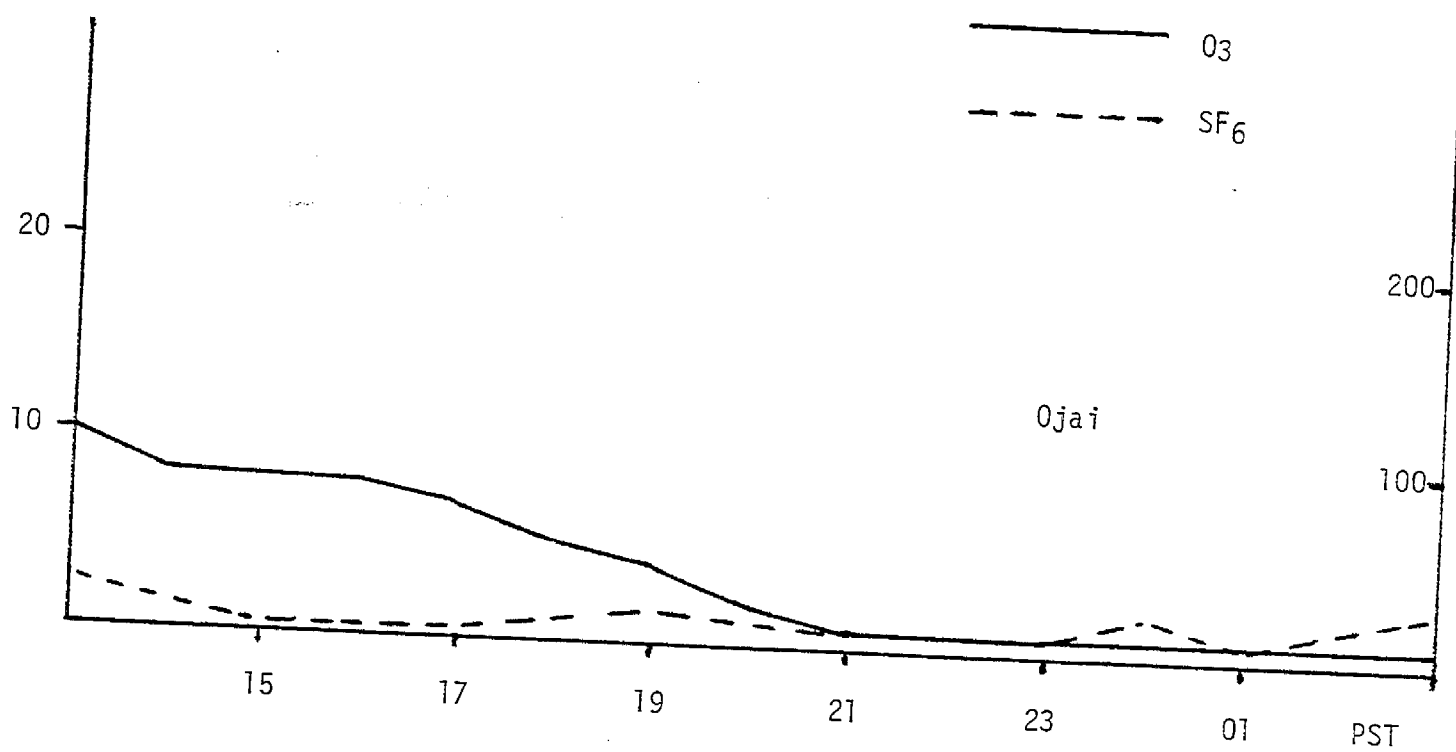
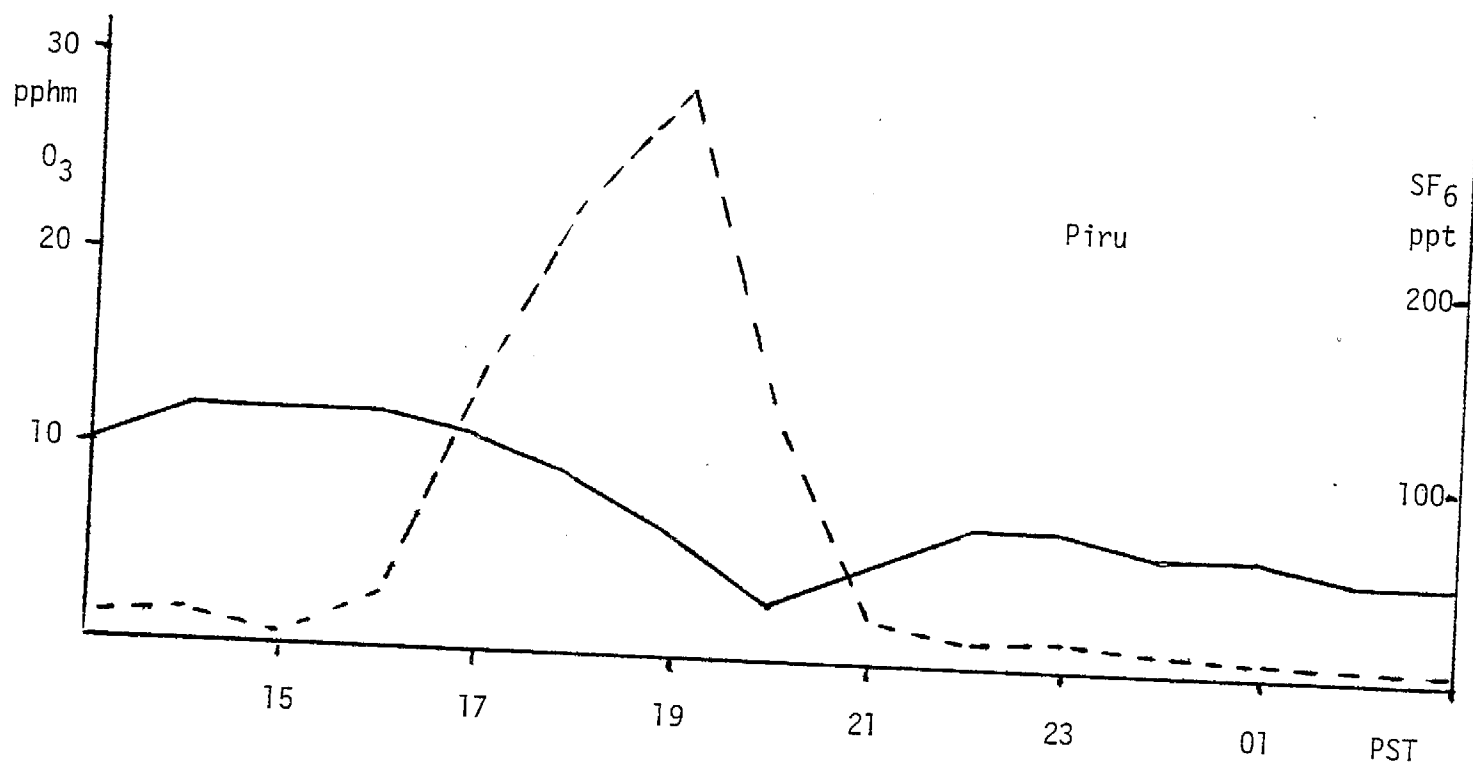
Xu/Q values for September 28 have been computed for observed maximum tracer concentrations at various locations. These values are given in Table 4.5.6.

Table 4.5.6

Calculated Xu/Q Values
Test 4 - September 28, 1980

Wind Speed	Location	Time	Type of Sample	Distance	Xu/Q (x 10 ⁻⁶)
2.6 m/s	Camarillo	23 PDT	H	42 km	.36 m ⁻²
	Piru	20	H	53	.73
	Santa Paula	20	H	30	3.01
	Thousand Oaks	20	H	43	.05
	Ventura	14	A	6	22.2
	Ventura	15	A	6	24.1
	Ventura	16	A	6	33.0
	Ventura	16	A	6	24.4
	Ventura	17	A	12	8.4
	W Santa Paula	18	A	25	2.5
	Santa Paula	17	A/C	25	3.2
	Ventura	14	A	6	5.25
	Ventura	15	A	6	5.02
	Ventura	15	A	6	12.68
	Ventura	17	A	6	12.42
	Ventura	18	A	6	7.83
	Ventura	19	A	6	6.99

H - Hourly sample
A - Automobile sample
A/C - Aircraft sample



HOURLY CONCENTRATIONS OF OZONE AND SF₆ - September 28, 1980

Fig. 4.5.14

These values have been plotted in Figure 4.5.15 for comparison with Pasquill stability categories. Highest Xu/Q values, representing maximum impact, correspond to stability categories E-F for both hourly and automobile samples. Other values shown on the graph may represent a lack of direct tracer impact at the location.

Total tracer dosage was calculated for the 24-hour period of maximum impact at each of the hourly sampling locations. These values are shown in Table 4.5.7.

Table 4.5.7
Total SF₆ Dosages
Test 4 - September 28, 1980

Location	Total Dosage	Number of Hours \geq 10 ppt
Santa Barbara	406 ppt	8
Carpinteria	245	10
Ojai	233	13
Ventura	607	18
Santa Paula	5549	24
Piru	944	13
Oxnard	1450	17
Camarillo	682	20
Thousand Oaks	151	9

Although the greatest short-term impact was observed near Ventura the location did not correspond to one of the hourly sampling locations. As a result Santa Paula showed the highest total dosage impact followed by Oxnard, Piru and Camarillo. Total number of hours with concentrations of 10 ppt or more were all quite large, ranging up to 24 hours at Santa Paula. This illustrates the importance of carry-over, particularly in the coastal and inland valleys of Ventura County.

A BLM release was carried out on September 27, the day before Test 4. A general background of 15-20 ppt was found in the area on the morning of September 28. In isolated pockets, higher values were found. Further details appear in a later section.

There were no automobile traverses carried out on September 29 since a BLM release was scheduled on that day.

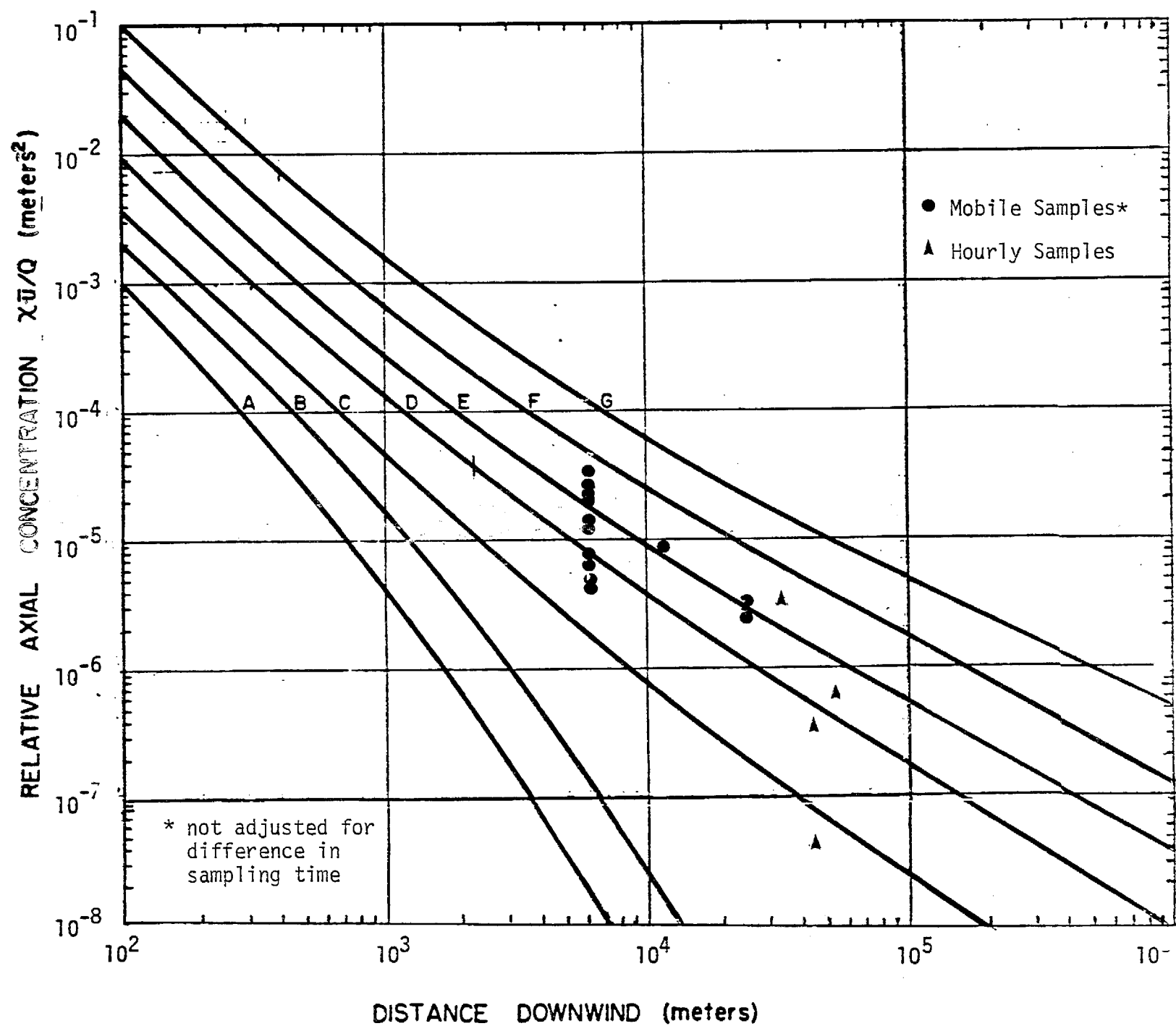


Fig. 4.5.15 XU/Q VALUES - Test 4

September 28, 1980

4.6 Test 5 1 October 1980 - Release from near Platform Grace
(0600-1100 PDT)

4.6.1 General Meteorology

A large surface high pressure area was centered in southern British Columbia with offshore winds from southern California to Washington (Figure 4.6.1). The thermal trough in California was located along the coast, resulting in warm temperatures inland. Skies were clear at Santa Barbara all day until near midnight when low clouds and fog developed. Pt. Mugu reported fog for several hours in the early morning and severely restricted visibility during the balance of the day.

Table 4.6.1 gives the significant meteorological parameters for October 1.

Table 4.6.1

Meteorological Parameters

October 1, 1980

850 mb Temperature (Vandenberg AFB)	25°C
Pressure Gradients (07 PST)	
LAX-Bakersfield	-2.8 mb
Santa Barbara-Daggett	-2.8 mb
Inversion Base (15 PST)	
Pt. Mugu	79 m
Maximum Surface Temperatures	
Thousand Oaks	100°F
Piru	108
Santa Barbara	80

Temperatures aloft at 850 mb warmed considerably from the conditions of the previous test on September 28. A temperature of 25°C is well above average for the time of year. Although the temperature aloft was slightly higher (27°C) on October 3, surface maximum temperatures inland were higher on October 1. A maximum of 108°F at Piru represents an exceptionally high value for early October. Pressure gradients were directed offshore for all values shown in the table.

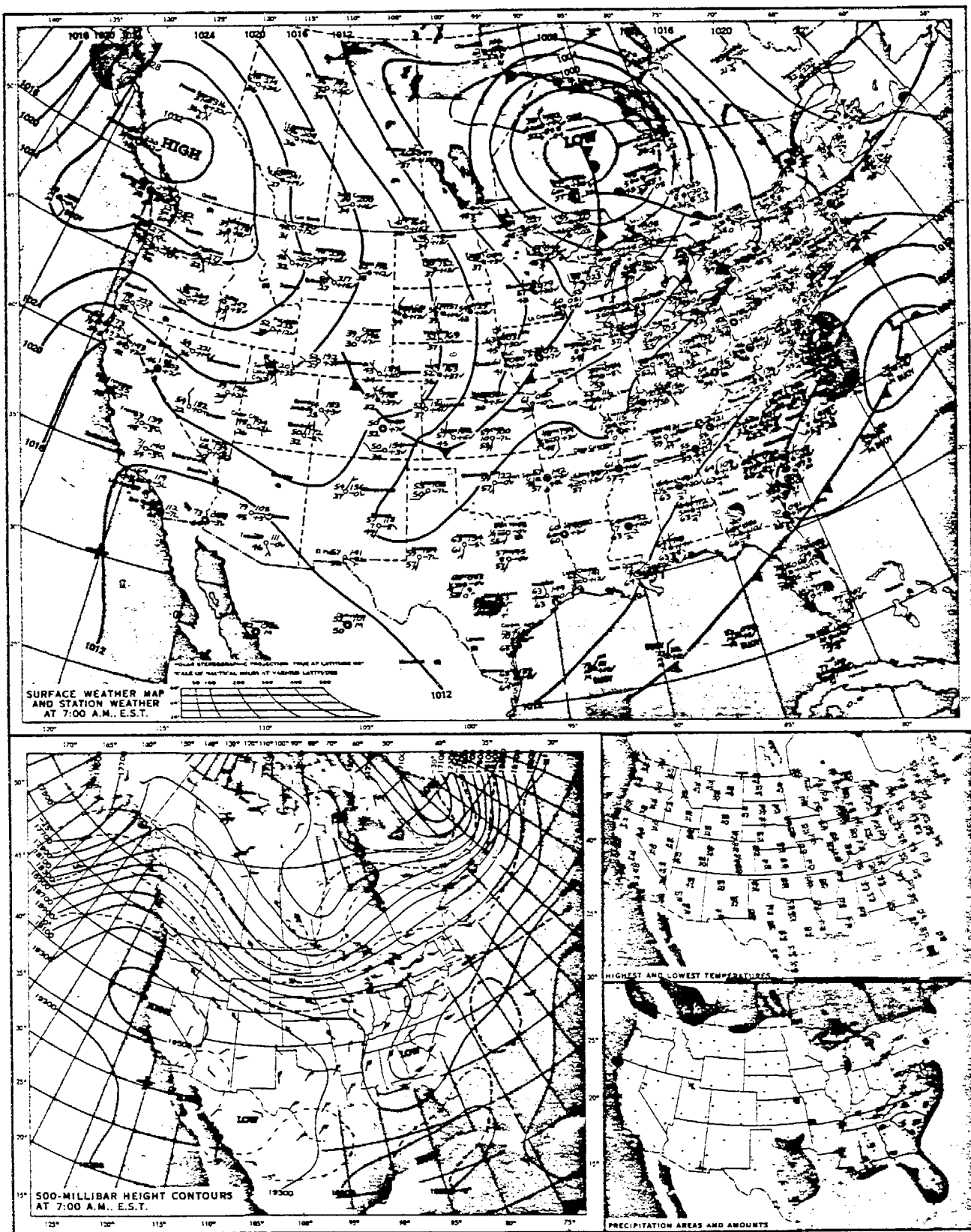


Fig. 4.6.1 WEATHER MAP - October 1, 1980

4.6.2 Transport Winds

Surface transport winds for October 1 are given in Table 4.6.2. At Pt. Conception easterly winds prevailed early in the morning and late in the evening. Velocities of 11-12 m/s from the east were recorded before midnight. At Hondo and Santa Barbara, east to southeast winds occurred in the morning and evening. The characteristic southwest winds associated with a temporary breakdown of the eddy were observed in the afternoon at both locations. Winds at Platform Grace were southeasterly through 14 PST and the normal afternoon seabreeze from the southwest was present only briefly. Wind velocities at Platform Grace were quite light. The seabreeze flow was also absent at Ventura with light south to southeast winds dominating the flow during the day.

Table 4.6.2
Transport Winds - Test 5

October 1, 1980

Time PST	Pt. Conception		Hondo		Santa Barbara		Grace		Ventura Surfers Point	
	w/d	w/s	w/d	w/s	w/d	w/s	w/d	w/s	w/d	w/s
06	105°	2.0m/s	093°	4.9m/s		Calm	115°	0.4m/s	125°	0.4m/s
08	112	1.8	102	1.3	120°	2.1	151	1.3	255	1.8
10	315	3.9	098	0.9	150	3.6	117	0.3	190	1.2
12	309	7.5	126	0.4	190	4.1	163	1.8	150	2.6
14	294	4.7	248	2.2	180	3.6	144	2.8	145	2.2
16	069	3.2	258	2.2	240	4.1	271	3.1	180	1.8
18	262	1.5	254	1.3		Calm	360	2.5	330	1.0
20	311	4.6	219	0.9	250	2.6	017	0.4	135	3.0
22	094	11.4		Calm	090	4.6	024	0.9	125	2.6
24	100	12.4	109	6.3	080	3.6	354	1.5	135	1.5

4.6.3 Mixing Heights

Mixing heights observed on October 1 by various methods are shown in Table 4.6.3. Intense heating resulted in deep, convective mixed layers at all inland stations. The cool, marine layer appeared in mid-afternoon at these stations as indicated by the aircraft soundings. Until late afternoon there was little evidence in any of the soundings of an upper pollutant layer. In the late afternoon indications of such a layer appeared in the Santa Susana and San Fernando Valley soundings. This layer occurred with northeasterly winds in contrast to the east to southeast winds on September 28 which brought much higher ozone values aloft. At Platform Grace there was an elevated pollutant layer with a top of 250 m-msl within a strong temperature inversion. The maximum ozone concentration of 14 pphm occurred at 200 m-msl and was not reflected in the surface concentration of 8 pphm. It appears that the surface mixed layer did not extend to 250 m but only to 100 m which represents the apparent base of the upper pollutant layer.

Table 4.6.3

Mixing Heights*

October 1, 1980

1. Measured by Sampling Aircraft

Time	Location	Height
1341 PDT	Ventura	300m
1403	Ojai	2500+
1449	Platform Grace (Upper layer at 200m)	100
1539	Piru	400
1600	Santa Paula Airport	200
1707	Ventura (Upper layer to 400m)	100
1746	Santa Susana Airport (Upper layer to 700m)	400
1805	W end of San Fernando Valley (Upper layer to 1000m)	300
1857	Santa Barbara	400

2. Measured by Pibals

Time	Santa Ynez	Ojai	Simi	Ventura
11 PDT	159m	263m	53m	53m
13	758	758	53	53
15	1165	852	758	53
17	159	1395	---	159
18	---	---	263	---
19	159	0	---	---

3. Measured by MRI Acoustic Sounder

Santa Paula Airport	Height
11 PDT	130 m
13	100
15	90
17	150
19	--
21	140

* Heights are above surface

4.6.4 Regional Ozone Concentrations

Maximum ozone concentrations at several stations in the area are shown in Table 4.6.4. Temperatures aloft increased compared to the value observed on September 28. As a consequence, maximum surface ozone concentrations also increased. Peak hourly values at Goleta, Piru, Simi Valley, South Mt., Thousand Oaks, Moorpark and El Rio all exceeded the state standard. Background ozone concentrations, as measured during the aircraft spirals, showed average values of 7-8 pphm, a relatively high value and comparable only to September 22 among the test days.

Time histories of the hourly ozone concentrations are plotted in Figure 4.6.2. Piru and Simi peaked at about 13-14 PST. Ojai shows a flat peak extending from 11-16 PST of only 9 pphm. Peak temperatures in the inland areas occurred rather early in the day (around 11 PST). Intense surface heating (111°F at upper Ojai) resulted in deep, convective mixing and the elimination of any stable layers. As noted in the previous section the measured mixing height at Ojai at 1403 PDT was over 2500 m with no evidence of a marine layer intrusion. The time history of the ozone concentrations at Ojai indicates that this condition continued through 16 PST and resulted in uniform, but comparatively low, surface ozone concentrations.

In contrast, Piru showed a sharp increase in surface ozone between 13 and 14 PST accompanying the arrival of the marine air. This cooler air served to keep the pollutants from mixing upward and resulted in the 15 pphm peak concentration at 14 PST. An aircraft sounding (see Section 4.6.5) at 1539 PDT clearly shows the presence of the marine layer and the increased ozone within that layer.

A similar layer was found in a sounding at Santa Susana Airport at 1746 PDT (see Table 4.6.3). Since the maximum temperature at Simi occurred at 10-11 PST while the peak ozone was observed at 14 PST, it is apparent that the principal ozone contribution came from the marine layer intrusion as was the case at Piru.

The plots of hourly ozone at Ventura and Pt. Hueneme show pronounced peaks at 22 and 21 PST, respectively. South to southeast winds prevailed along the coast at this time. The peak at Platform Grace occurred during mid-afternoon, also with a southerly wind. The source of the late evening ozone is not clear but transport over-water from the South Coast Air Basin is a significant possibility.

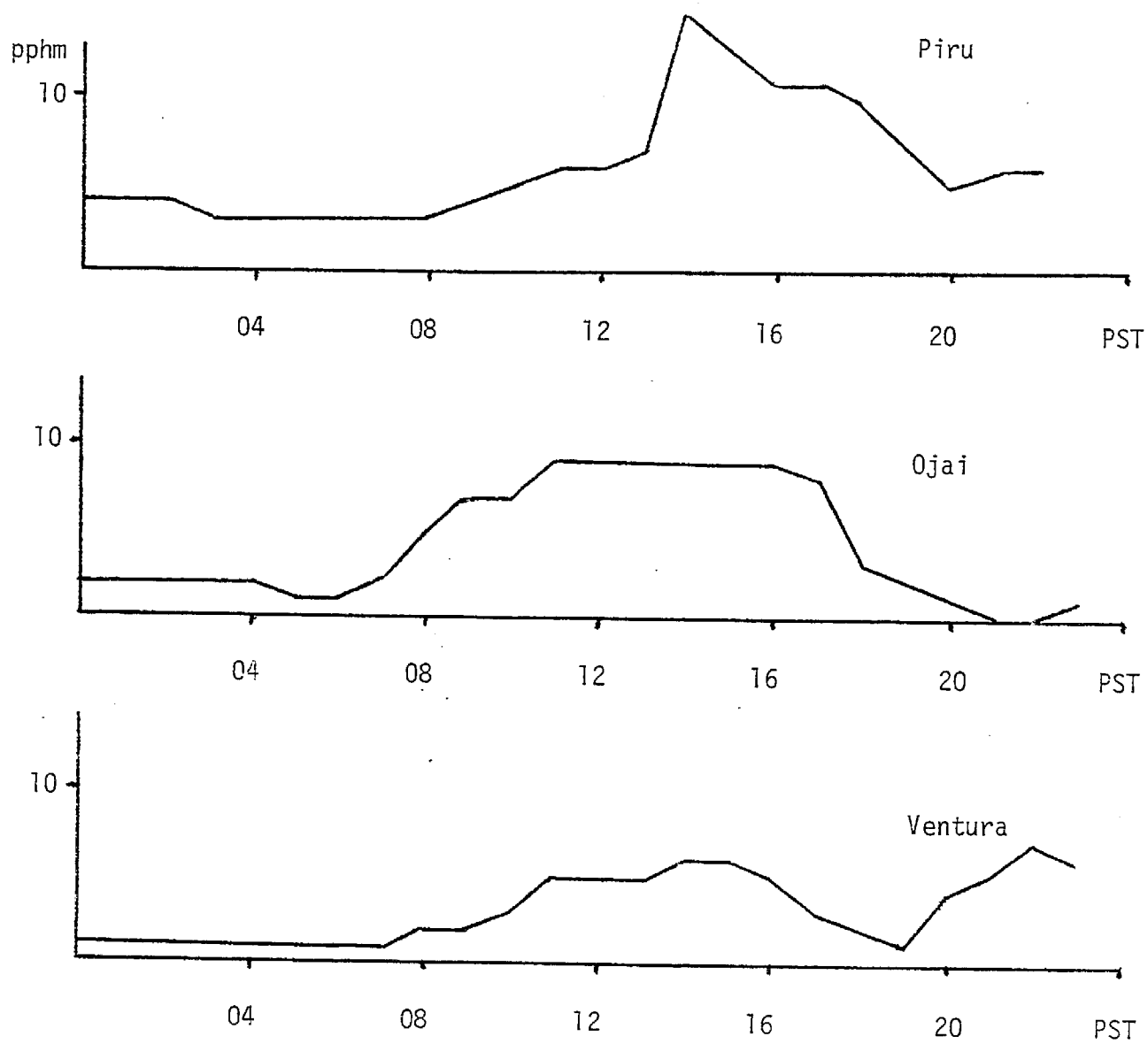


Fig. 4.6.2a HOURLY OZONE CONCENTRATIONS - October 1,1980

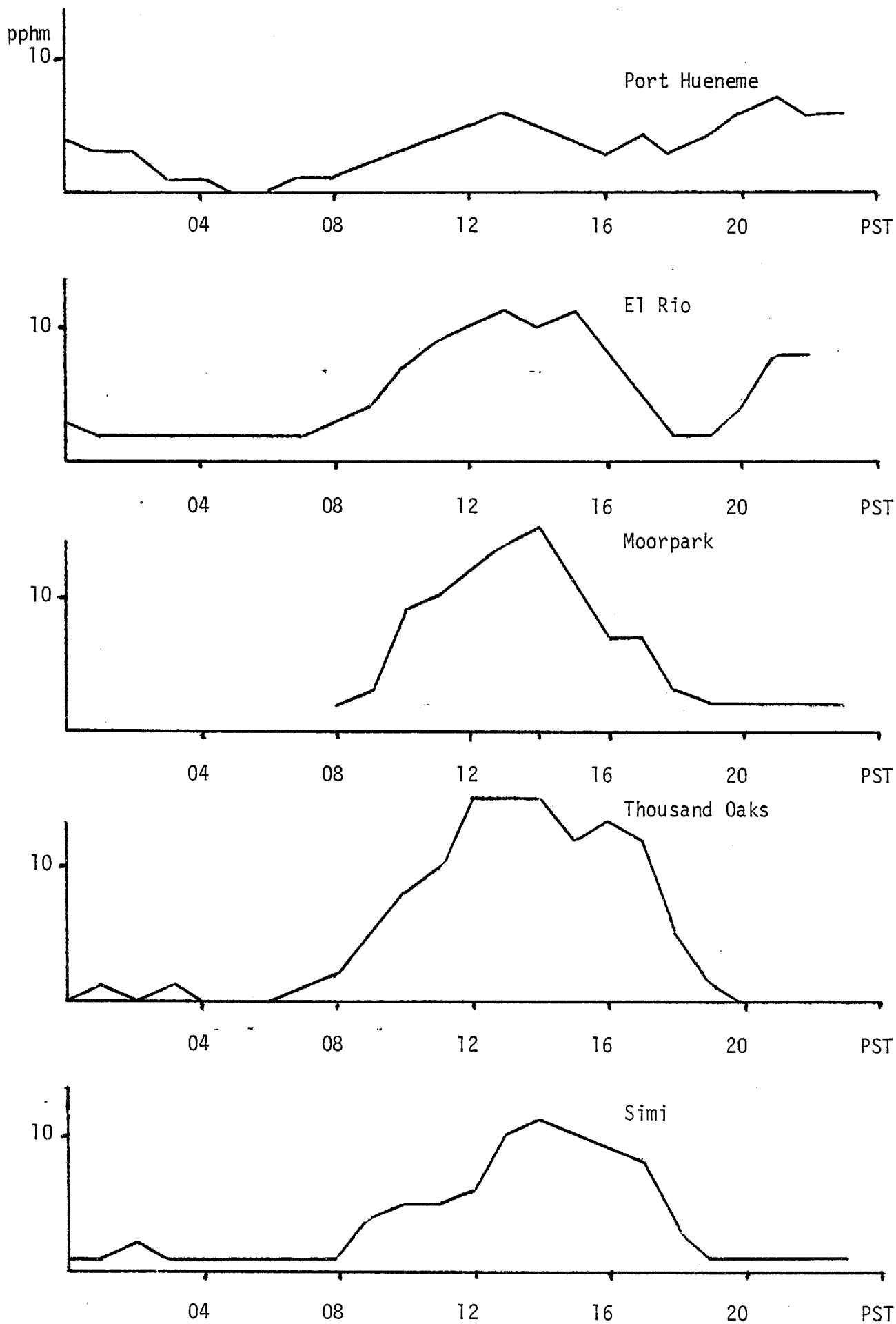


Fig. 4.6.2b HOURLY OZONE CONCENTRATIONS - October 1, 1980
4-109

Table 4.6.4

Regional Maximum Ozone Concentrations (pphm)

October 1, 1980

Location	Max O ₃	Time of Max (PST)	Wind Direction at Time of Max	Time of Max Temp (PST)
Pt. Conception	8	13	311°	17
Goleta	11	15	200	13
Platform Hondo	8	12-14	126-248	
Ojai	9	11-16	165,300	11-12
Piru	15	14	255	11
Simi Valley	11	14	280	10-11
South Mt.	12	12-13	190	11
Thousand Oaks	15	12-14	320	08
Moorpark	15	14	M	M
El Rio	11	13,15	M	M
Ventura	7	22	125	11
Pt. Hueneme	7	21	180*	11*
Platform Grace	8	14-15	170	16

Background 7-8

*Pt. Mugu

4.6.5 Aircraft Sampling

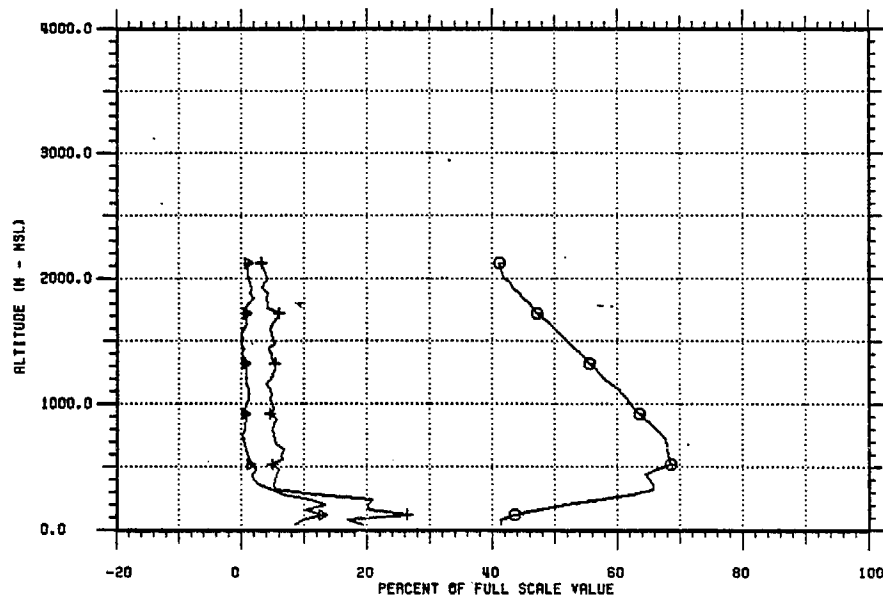
The aircraft sampling on October 1 was concentrated primarily in the vicinity of Ventura and inland valleys including Ojai, Piru and Simi. Soundings were also made near Santa Barbara and in the offshore area near Platform Grace.

The first sounding was made near the Ventura Marina at 1341 PDT (Figure 4.6.3). A strong, low-level temperature inversion was present marked by elevated levels of O₃, NO_x, SO₂ and bscat. Depth of the layer was about 300 m which represented the depth of the marine layer at that location. West to southwest winds were present in this layer. Peak ozone value in the layer was 17 pphm with a sharp reduction to 11 pphm near the surface.

A horizontal traverse from Ventura to Ojai at 213 m-msl beginning at 1357 PDT demonstrated the marked changes which occur from the coast inland (Figure 4.6.4). Note first the large change in temperature at a constant elevation of 213 m-msl. A temperature change of 15-20°C occurred from the beginning of the traverse to the end. This resulted in an increase of the mixed layer from the coast inland and a consequent decrease in pollutant concentrations. Peak bscat and SO₂ concentrations occurred at 6-7 km inland while NO_x and O₃ peaks occurred slightly later along the traverse. The ozone level at the start of the traverse was 16 pphm but decreased rapidly a short distance from the coast.

SANBOX STUDY
SPIRAL AT POINT 1

TAPE/PASS: 185/2 DATE: 10/1 /80
TIME: 1341 TO 1355 (PDT)



821201.0
17:01:58

AIRCRAFT SOUNDING NEAR VENTURA MARINA

(1341 PDT)

October 1, 1980

SANBOX STUDY
SPIRAL AT POINT 1

TAPE/PASS: 185/2 DATE: 10/1 /80
TIME: 1341 TO 1355 (PDT)

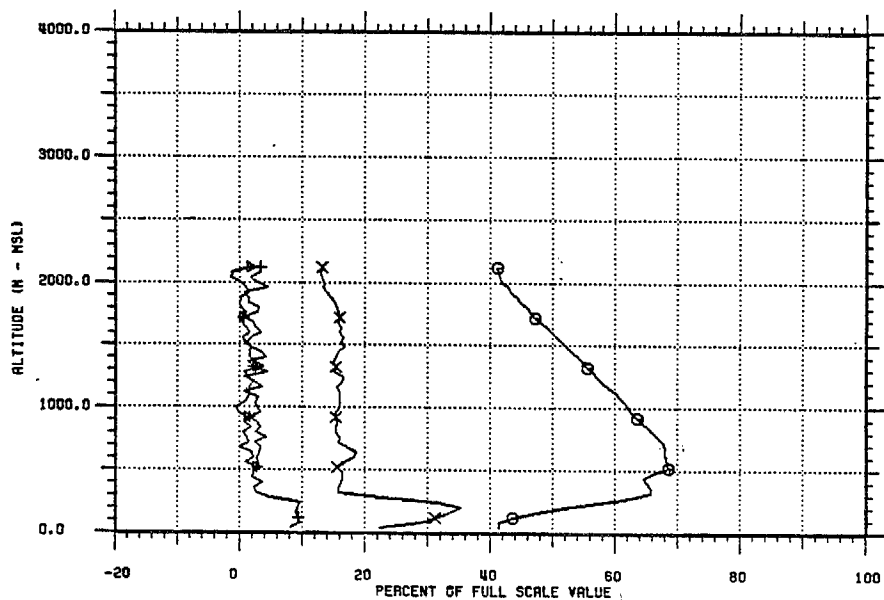


Fig. 4.6.3

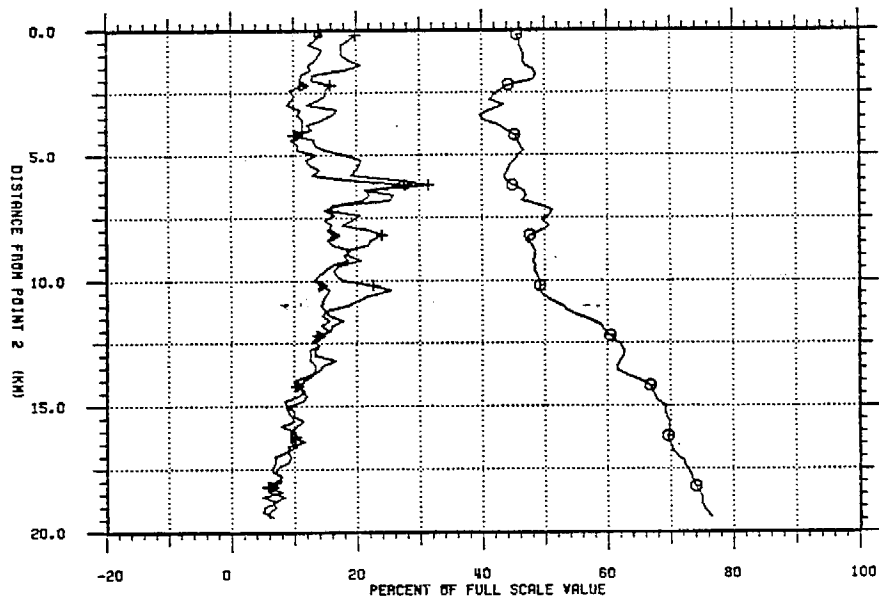
821201.0
17:01:58

SANBOX STUDY

TRAVERSE FROM POINT 2 TO POINT 3 (213 M MSL)

TAPE/PASS: 185/3 DATE: 10/1 /80

TIME: 1357 TO 1402 (PDT)



FULL SCALE VALUE

⊙ TEMP	50.	DEG. C
▴ SO ₂	100.	PPB
+ Pscat	1000.	10 ⁻⁶ M ⁻¹

821201.0
17:01:58

AIRCRAFT TRAVERSE - VENTURA TO OJAI

(1357 PDT)

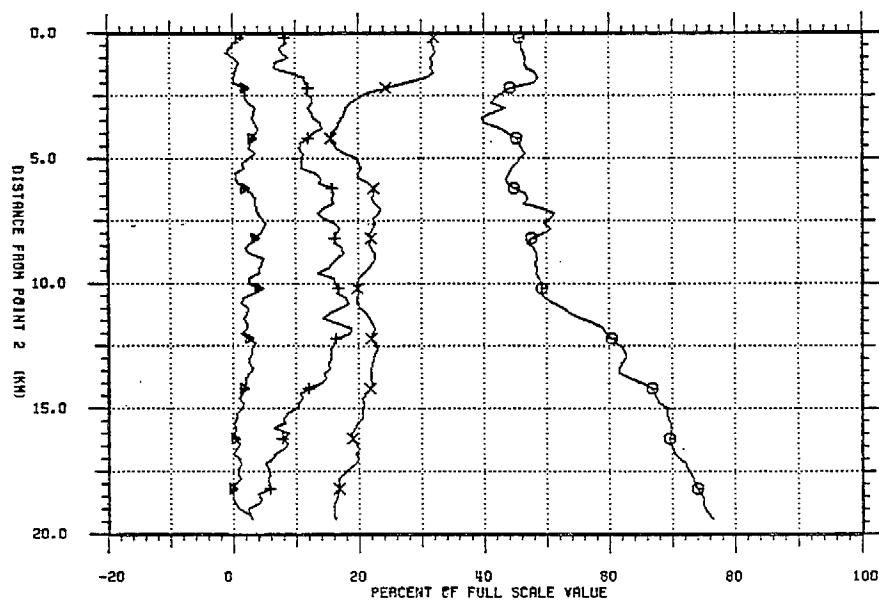
October 1, 1980

SANBOX STUDY

TRAVERSE FROM POINT 2 TO POINT 3 (213 M MSL)

TAPE/PASS: 185/3 DATE: 10/1 /80

TIME: 1357 TO 1402 (PDT)



FULL SCALE VALUE

⊙ TEMP	50.	DEG. C
▴ NO	200.	PPB
+ NO _x	200.	PPB
× SO ₂	500.	PPB

821201.0
17:01:58

Fig. 4.6.4

The sounding at Ojai (Figure 4.6.5) at 1403 PDT confirms the presence of a deep, mixed layer with strong, surface heating (38°C). An adiabatic temperature sounding was observed to 2500 m-msl. Pollutant parameters were uniform with height, representing a well-mixed layer. Ozone levels ranged from 7-9 pphm throughout the sounding. Peak ozone level for the day at the surface was 9 pphm.

A horizontal traverse was flown from Carpinteria to Platform Grace at a height of 183 m-msl beginning at 1440 PDT (Figure 4.6.6). All measured parameters showed uniform concentrations but ozone values were relatively high (13-14 pphm) throughout the traverse. These data confirmed the offshore ozone characteristics measured earlier at Ventura and pointed out the widespread nature of the ozone layer.

The sounding at Platform Grace (1449 PDT) is shown in Figure 4.6.7. A strong surface temperature inversion was present representing very warm air aloft undercut by the cool surface temperatures. The pollutant profiles indicate a mixed layer of about 200-250m depth. Peak ozone concentration was 14 pphm, again indicating the shallow but extensive horizontal character of the layer. Peak ozone concentration at the Grace platform was 8 pphm at about the time of the sounding.

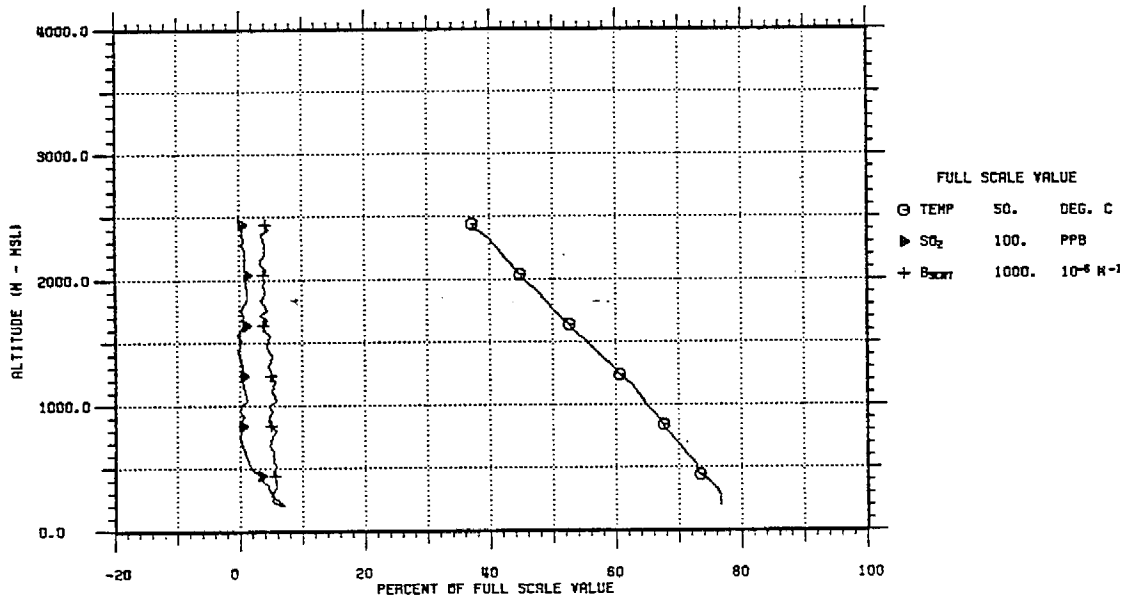
A horizontal traverse from Platform Grace to Ventura, shown in Figure 4.6.8, began at 1519 PDT. The elevation was 213 m-msl which was still within the offshore pollution layer. Ozone concentrations were 13-14 pphm throughout the traverse except for a brief increase to 17 pphm slightly offshore. All observed pollutant parameters showed a similar increase at this location.

The traverse continued from Ventura to Piru (Figure 4.6.9) at 305 m-msl. As in the traverse to Ojai shown earlier, a substantial increase in temperature was observed along the flight path. Ozone levels increased sharply just inland from the coast to a level of 22 pphm but then ranged 12-14 pphm for the balance of the traverse. These values were significantly greater than observed earlier on the traverse from Ventura to Ojai.

A sounding was then made at Piru (Figure 4.6.10) at 1539 PDT. There is a slightly stable layer apparent in the sounding above 550 m-msl. The effect of this stability is shown in the pollutant profiles with ozone concentrations to 14 pphm below that level and 8-10 pphm above. The upper ozone layer is comparable to that observed earlier at Ojai. The lower layer represents an undercutting of marine air from the coast with restricted vertical mixing and higher ozone layers. Between 12 and 15 PDT the surface temperature at Piru decreased 6°F and the surface ozone concentration increased from 6 to 15 pphm as the marine air passed the station. As indicated, the maximum surface temperature occurred prior to the arrival of the marine air; the maximum ozone concentration occurred within the marine air.

SANBOX STUDY
SPIRAL AT POINT 3

TAPE/PASS: 185/4 DATE: 10/1 /80
TIME: 1403 TO 1429 (PDT)

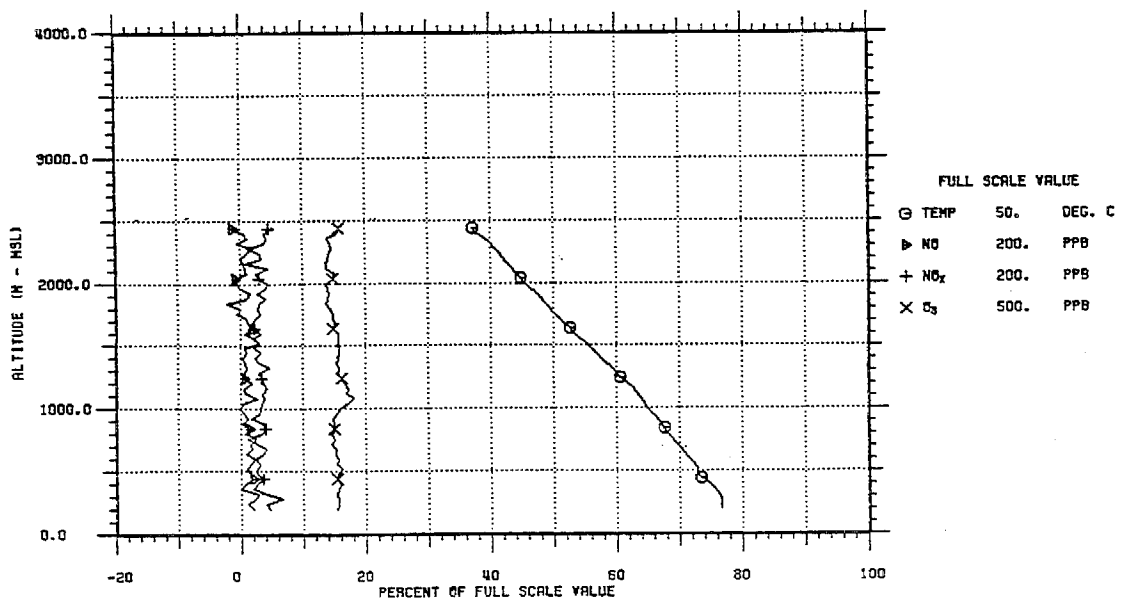


821201.0
17:01:58

AIRCRAFT SOUNDING AT OJAI
(1403 PDT)
October 1, 1980

SANBOX STUDY
SPIRAL AT POINT 3

TAPE/PASS: 185/4 DATE: 10/1 /80
TIME: 1403 TO 1429 (PDT)



821201.0
17:01:58

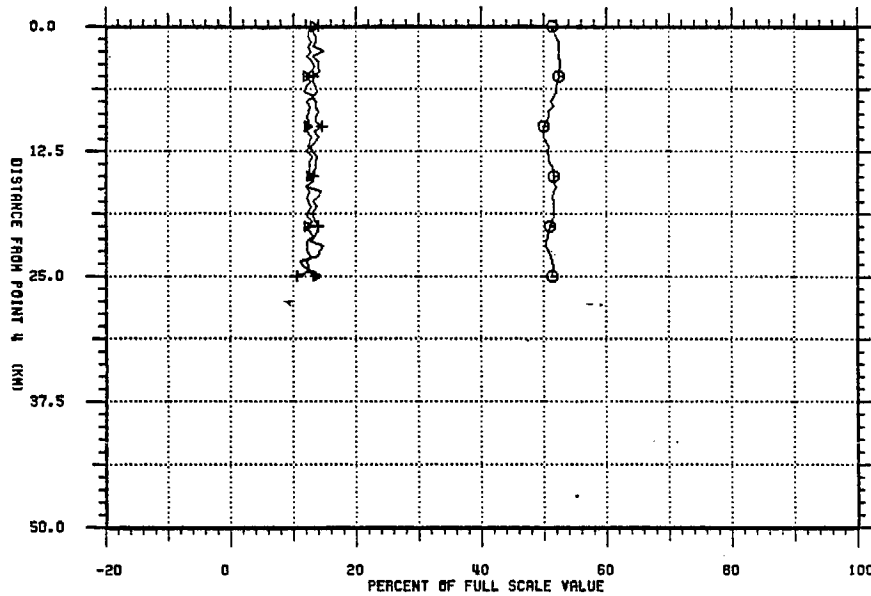
Fig. 4.6.5

SANBOX STUDY

TRAVERSE FROM POINT 4 TO POINT 5 (183 M MSL)

TAPE/PASS: 185/6 DATE: 10/1 /80

TIME: 1440 TO 1448 (PDT)



FULL SCALE VALUE

⊖ TEMP	50.	DEG. C
▷ SO ₂	100.	PPB
+ O ₃	1000.	10 ⁻⁶ M ⁻¹

821201.0
17:01:58

AIRCRAFT TRAVERSE- CARPINTERIA TO GRACE

(1440 PDT)

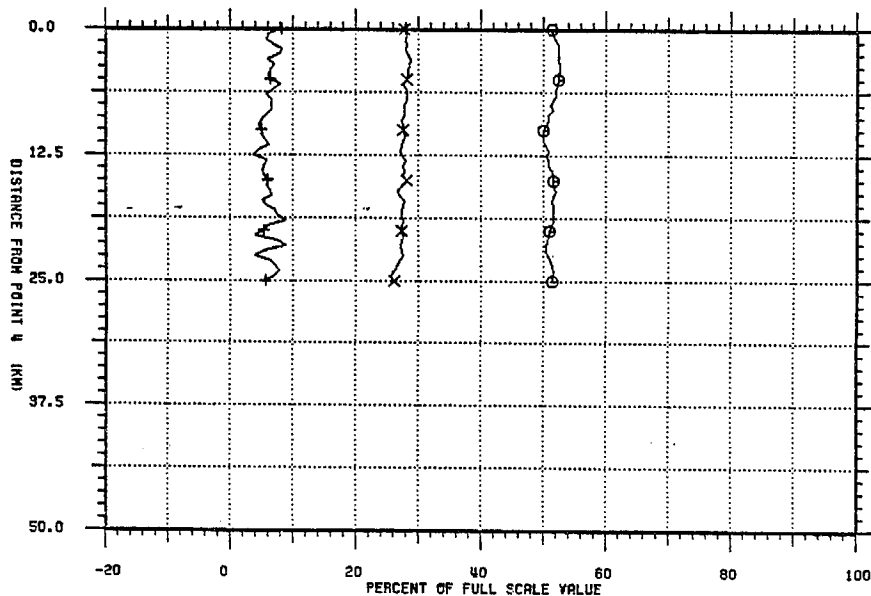
October 1, 1980

SANBOX STUDY

TRAVERSE FROM POINT 4 TO POINT 5 (183 M MSL)

TAPE/PASS: 185/6 DATE: 10/1 /80

TIME: 1440 TO 1448 (PDT)



FULL SCALE VALUE

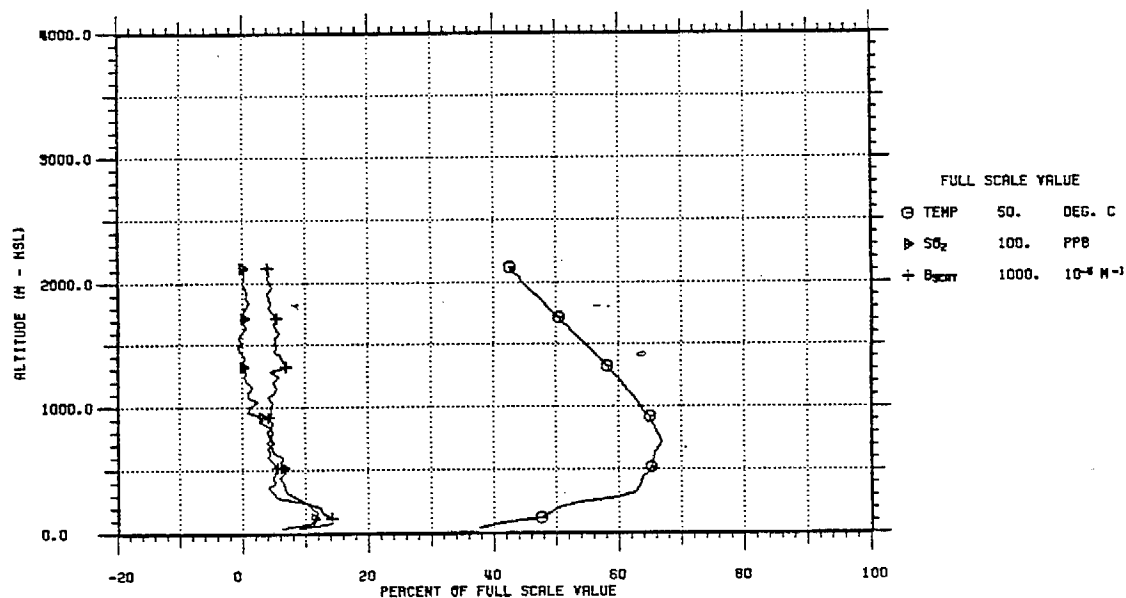
⊖ TEMP	50.	DEG. C
▷ NO	1000.	PPB
+ NO _x	200.	PPB
× O ₃	500.	PPB

821201.0
17:01:58

Fig. 4.6.6

SANBOX STUDY
SPIRAL AT POINT 5

TAPE/PASS: 185/7 DATE: 10/1 /80
TIME: 1449 TO 1505 (PDT)



821201.0
17:01:58

AIRCRAFT SOUNDING AT PLATFORM GRACE

(1449 PDT)

October 1, 1980

SANBOX STUDY
SPIRAL AT POINT 5

TAPE/PASS: 185/7 DATE: 10/1 /80
TIME: 1449 TO 1505 (PDT)

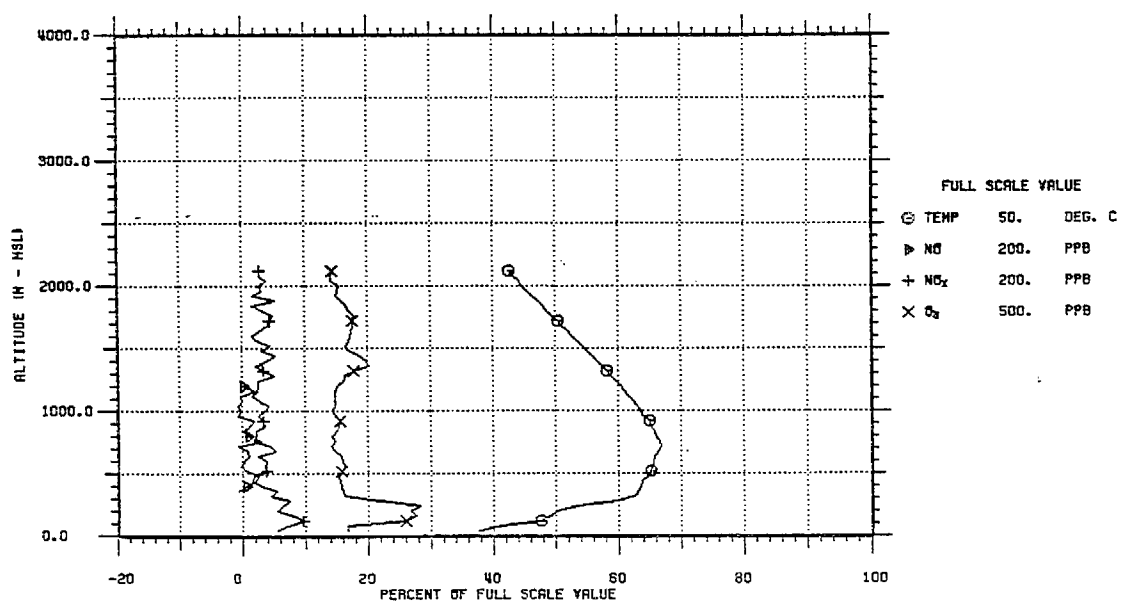


Fig. 4.6.7

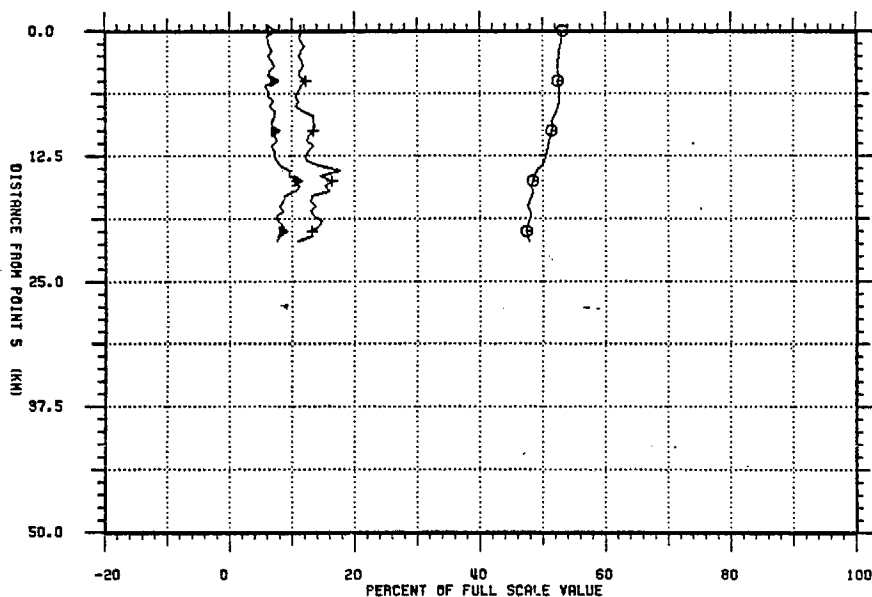
821201.0
17:01:58

SANBOX STUDY

TRAVERSE FROM POINT 5 TO POINT 1 (213 M MSL)

TAPE/PASS: 185/9 DATE: 10/1 /80

TIME: 1519 TO 1524 (PDT)



FULL SCALE VALUE
 ⊙ TEMP 50. DEG. C
 ▷ SO₂ 100. PPB
 + Backscat 1000. 10⁻⁶ M⁻¹

821201.0
 17:01:58

AIRCRAFT TRAVERSE - GRACE TO VENTURA

(1519 PDT)

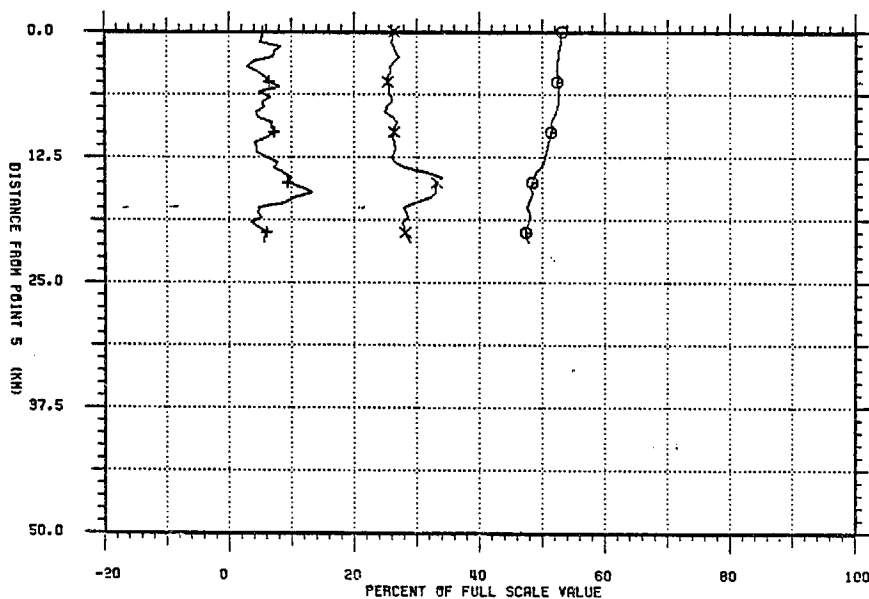
October 1, 1980

SANBOX STUDY

TRAVERSE FROM POINT 5 TO POINT 1 (213 M MSL)

TAPE/PASS: 185/9 DATE: 10/1 /80

TIME: 1519 TO 1524 (PDT)



FULL SCALE VALUE
 ⊙ TEMP 50. DEG. C
 ▷ NO 1000 PPB
 + NO_x 200. PPB
 × O₃ 500. PPB

821201.0
 17:01:58

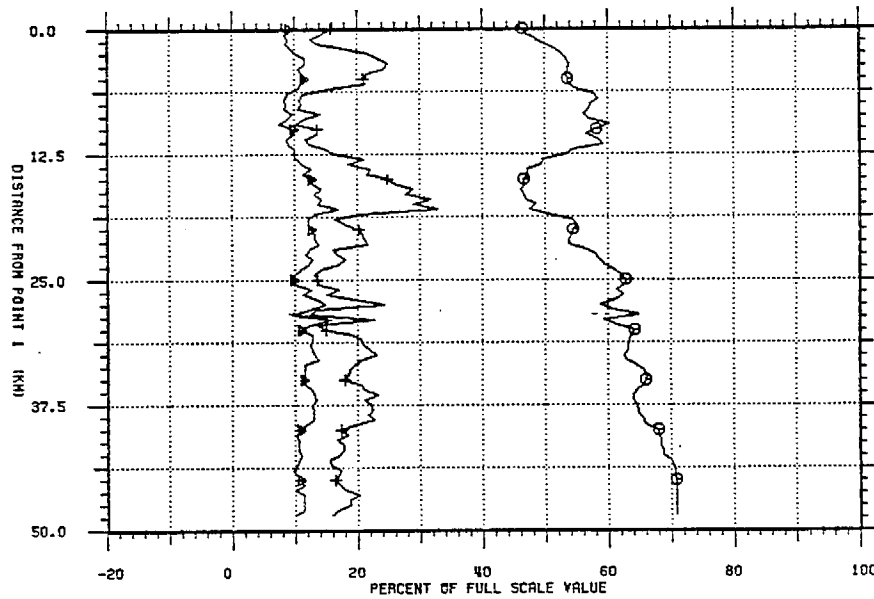
Fig. 4.6.8

SANBOX STUDY

TRAVERSE FROM POINT 1 TO POINT 6 (305 M MSL)

TAPE/PASS: 185/10 DATE: 10/1 /80

TIME: 1525 TO 1539 (PDT)



FULL SCALE VALUE
 ○ TEMP 50. DEG. C
 ▴ SO₂ 100. PPB
 + Bar 1000. 10⁻⁶ M⁻¹

821201.0
17:01:58

AIRCRAFT TRAVERSE - VENTURA TO PIRU

(1525 PDT)

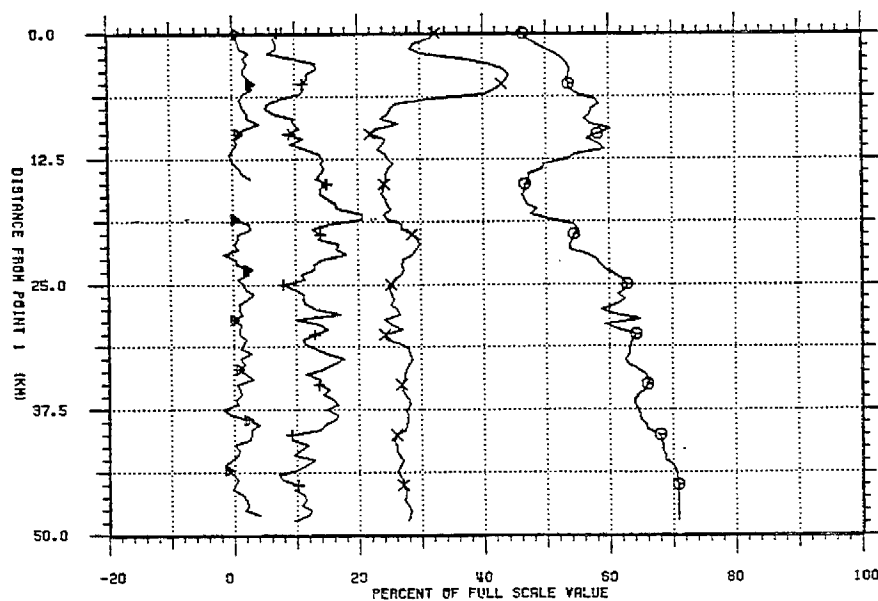
October 1, 1980

SANBOX STUDY

TRAVERSE FROM POINT 1 TO POINT 6 (305 M MSL)

TAPE/PASS: 185/10 DATE: 10/1 /80

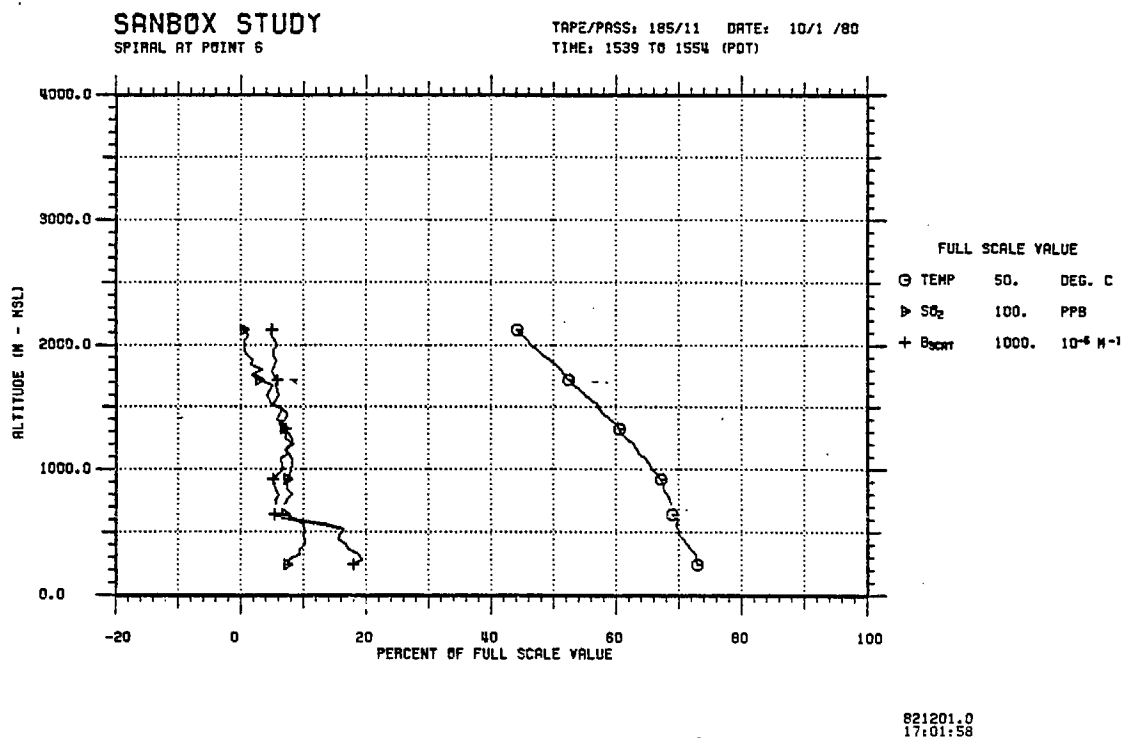
TIME: 1525 TO 1539 (PDT)



FULL SCALE VALUE
 ○ TEMP 50. DEG. C
 ▴ NO 200. PPB
 + NO_x 200. PPB
 × O₂ 500. PPB

821201.0
17:01:58

Fig. 4.6.9



AIRCRAFT SOUNDING AT PIRU
(1539 PDT)
October 1, 1980

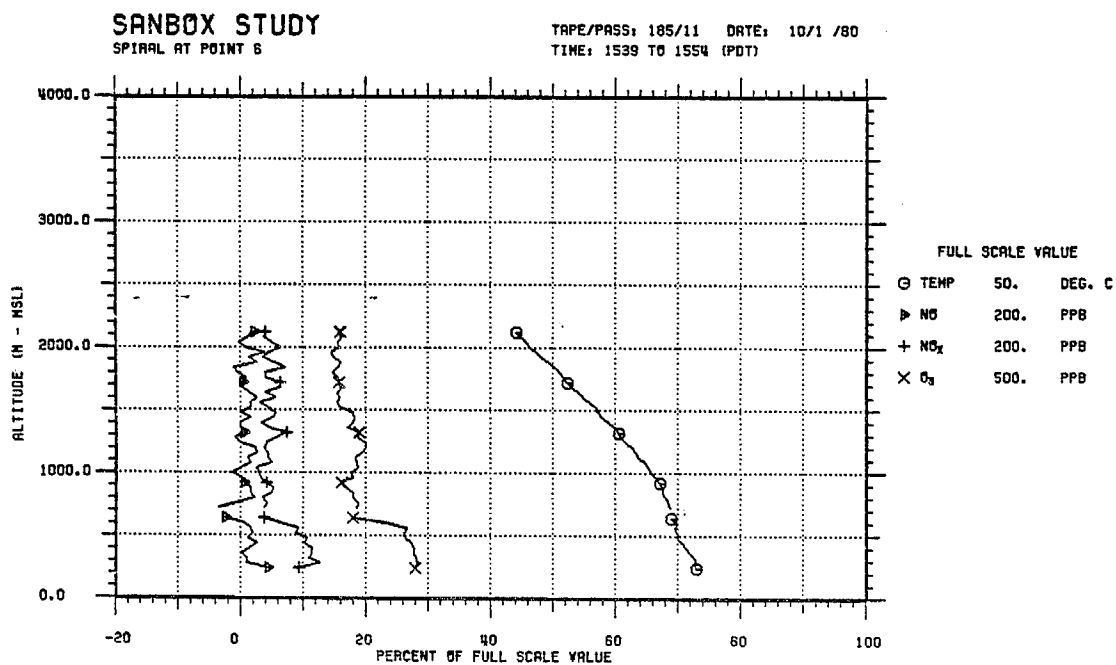


Fig. 4.6.10

The spiral at Santa Paula Airport (Figure 4.6.11) at 1600 PDT shows the presence of the marine air intrusion even more dramatically. The surface temperature is shown as 27°C (81°F) in contrast to the more strongly modified marine air seen at Piru. The depth of the layer is indicated as about 200 m. Peak ozone concentration in the marine air was 13-14 pphm with values of 9-10 pphm aloft.

The sounding in Figure 4.6.12 was made over the water at Ventura Marina at 1707 PDT. An intense surface inversion was present due to the warm temperatures aloft and the cool water temperatures at the surface. Pibal observations at the same location showed a shallow layer (150m) of southwest winds capped by a deep layer (to 1900m) of west to northwest winds. Northeasterly winds began at 2000 m-msl. ..

Two layers of pollutants were present in the air moving onshore from the southwest. Peak ozone values of 16-17 pphm were observed. Aloft ozone values ranged from 8-9 pphm in the layer that was moving onshore from the west and northwest. The effects of this upper layer have been previously described at Simi and Piru.

The sounding in Figure 4.6.13 took place at Santa Susana Airport (Simi) at 1746 PDT. The temperature structure shows a slight inversion at about 700 m-msl which represents the intrusion of marine air. Peak ozone concentration in the marine layer was about 14 pphm with gradually decreasing values aloft. Peak surface ozone concentration measured at Simi was 11 pphm at 15 PDT. Upper wind measurements at Simi showed a layer of westerly winds from the surface to 263 m topped by a layer of northwesterly winds to 1300 m-msl. Above this level winds were from the northeast. Comparison with the soundings in Fig. 4.6.13 indicates that the ozone levels decreased in the layer of northeasterly winds.

The sounding made at the west edge of the San Fernando Valley (Figure 4.6.14) at 1805 PDT is notable primarily in comparison with a similar sounding on September 28 where peak ozone values of 22 pphm were observed at a level of 1000 m-msl in southeasterly winds. On October 1 winds at that level appeared to be from the northwest and no similar peak was observed.

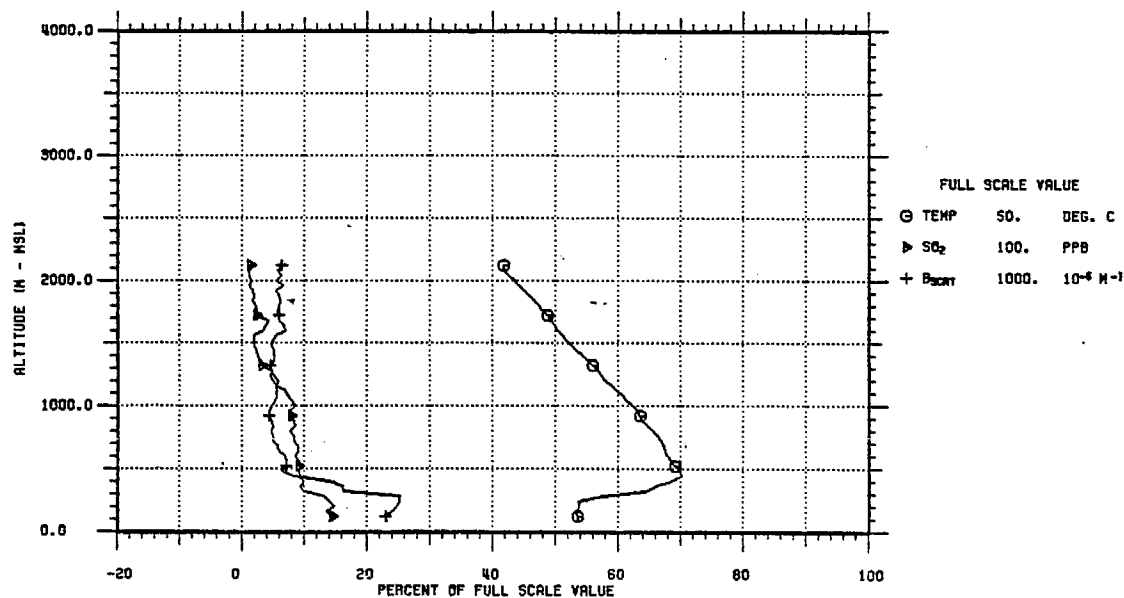
Figure 4.6.15 represents a horizontal traverse at 122 m-msl beginning at 1842 PDT on a direct line from Ventura to Santa Barbara. Ozone concentrations varied markedly along the route with a minimum of 9 pphm approximately in the middle of the traverse. The same pattern was apparent in the bscat and SO₂ traces while NO_x followed a somewhat different characteristic.

The final sounding was made at 1857 PDT near the coast at Santa Barbara (Figure 4.6.16). Although there was a low-level inversion present to 300 m-msl, there appeared to be no accumulation of pollutants in this layer. Average ozone concentrations were about 7 pphm to 1800 m-msl, indicating a relatively high background level throughout the area.

SANBOX STUDY

SPIRAL AT POINT 7

TAPE/PASS: 185/12 DATE: 10/1 /80
TIME: 1550 TO 1612 (PDT)



821201.0
17:01:58

AIRCRAFT SOUNDING AT SANTA PAULA

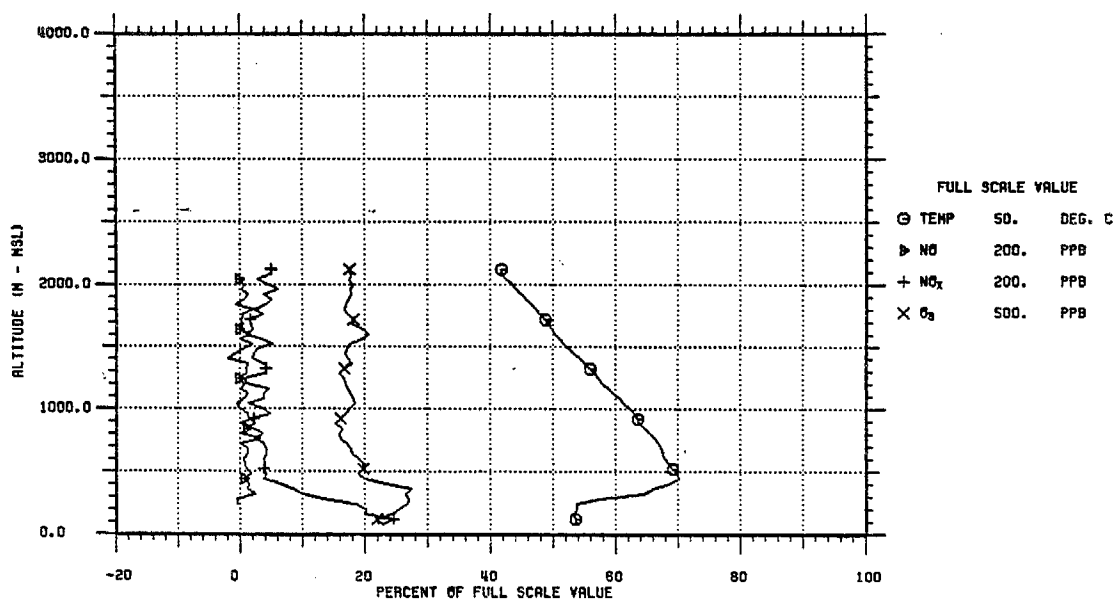
(1600 PDT)

October 1, 1980

SANBOX STUDY

SPIRAL AT POINT 7

TAPE/PASS: 185/12 DATE: 10/1 /80
TIME: 1550 TO 1612 (PDT)

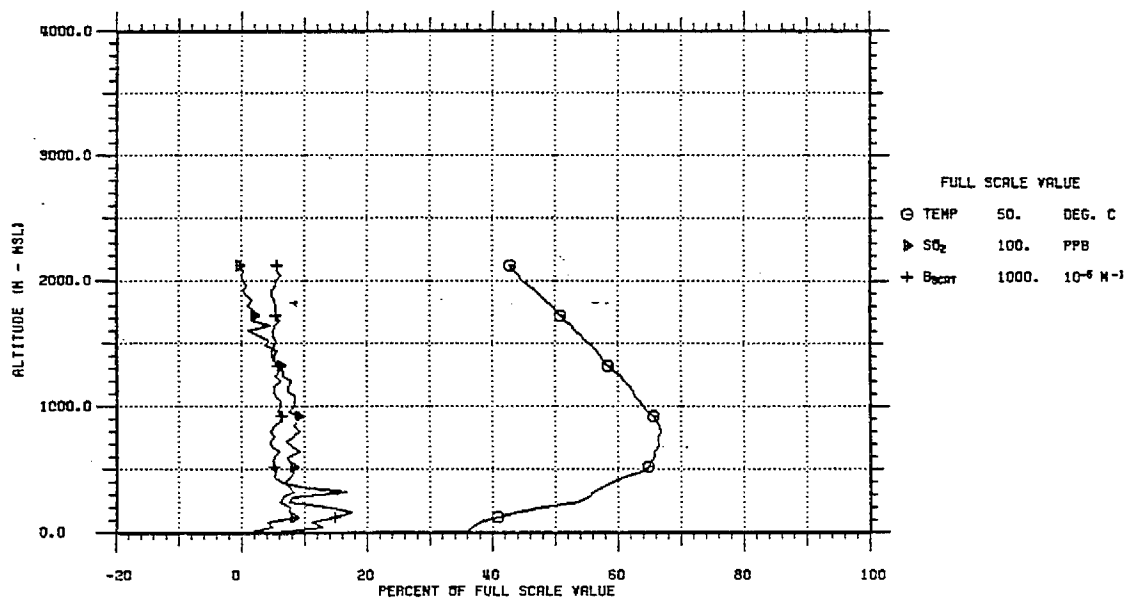


821201.0
17:01:58

Fig. 4.6.11

SANBOX STUDY
SPIRAL AT POINT 1

TAPE/PASS: 185/14 DATE: 10/1 /80
TIME: 1707 TO 1723 (PDT)



821201.0
17:01:58

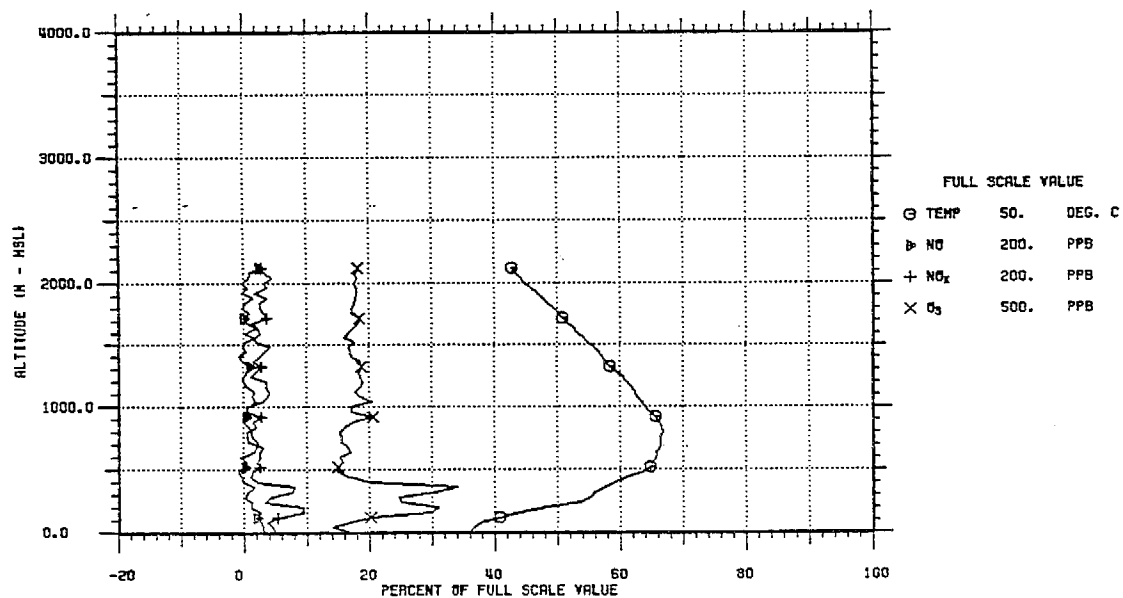
AIRCRAFT SOUNDING NEAR VENTURA MARINA

(1707 PDT)

October 1, 1980

SANBOX STUDY
SPIRAL AT POINT 1

TAPE/PASS: 185/14 DATE: 10/1 /80
TIME: 1707 TO 1723 (PDT)

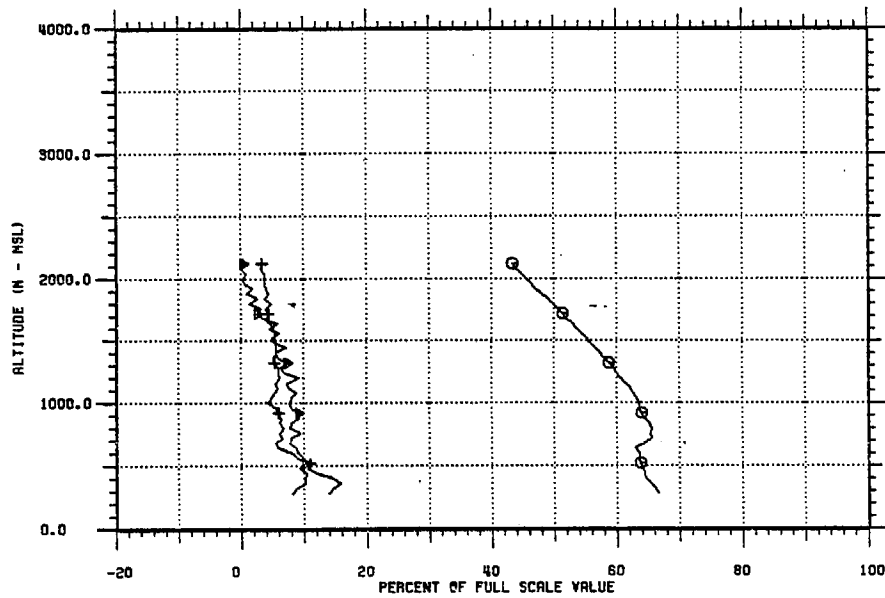


821201.0
17:01:58

Fig. 4.6.12

SANBOX STUDY
SPIRAL AT POINT 10

TAPE/PASS: 185/17 DATE: 10/1 /80
TIME: 1746 TO 1801 (PDT)



821201.0
17:01:59

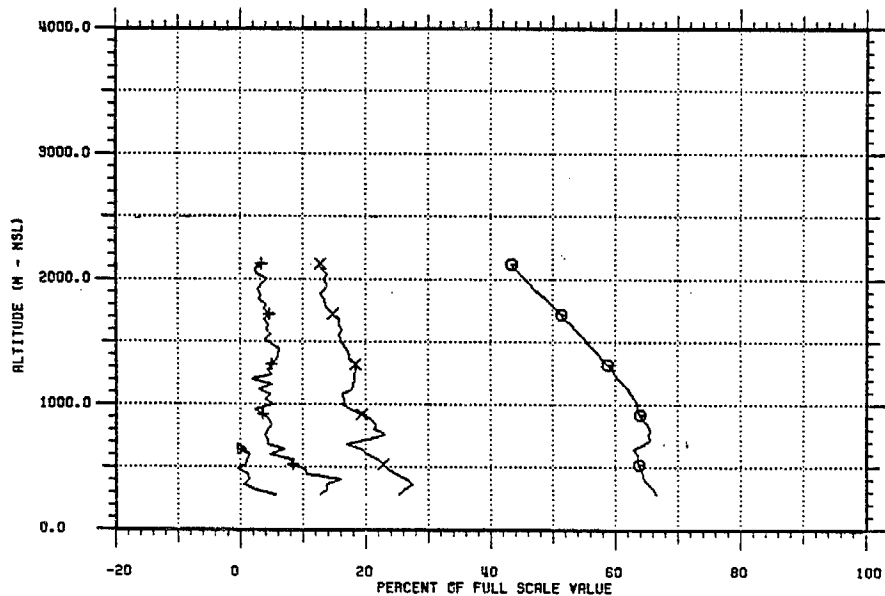
AIRCRAFT SOUNDING AT SANTA SUSANA

(1746 PDT)

October 1, 1980

SANBOX STUDY
SPIRAL AT POINT 10

TAPE/PASS: 185/17 DATE: 10/1 /80
TIME: 1746 TO 1801 (PDT)

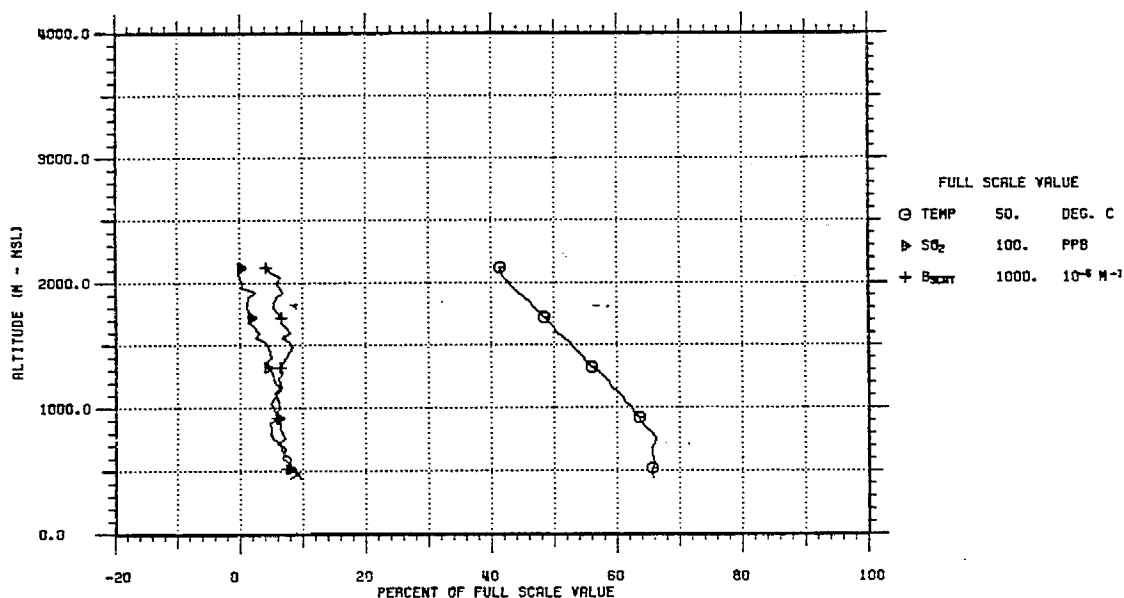


821201.0
17:01:58

Fig. 4.6.13

SANBOX STUDY
SPIRAL AT POINT 11

TAPE/PASS: 185/18 DATE: 10/1 /80
TIME: 1805 TO 1816 (PDT)

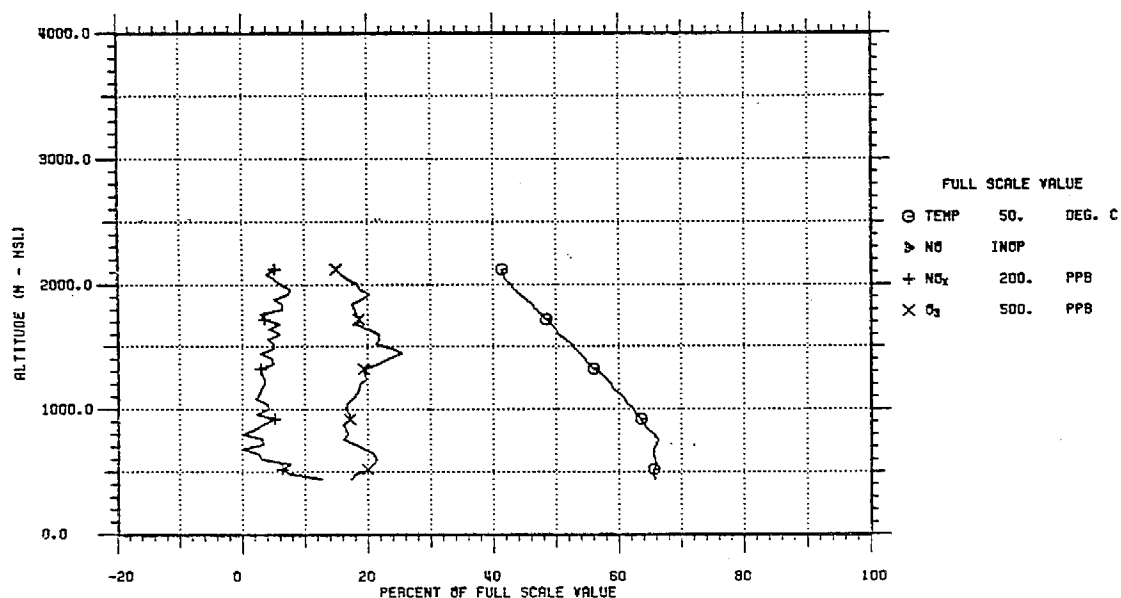


821201.0
17:01:58

AIRCRAFT SOUNDING - W SAN FERNANDO VALLEY
(1805 PDT)
October 1, 1980

SANBOX STUDY
SPIRAL AT POINT 11

TAPE/PASS: 185/18 DATE: 10/1 /80
TIME: 1805 TO 1816 (PDT)



821201.0
17:01:58

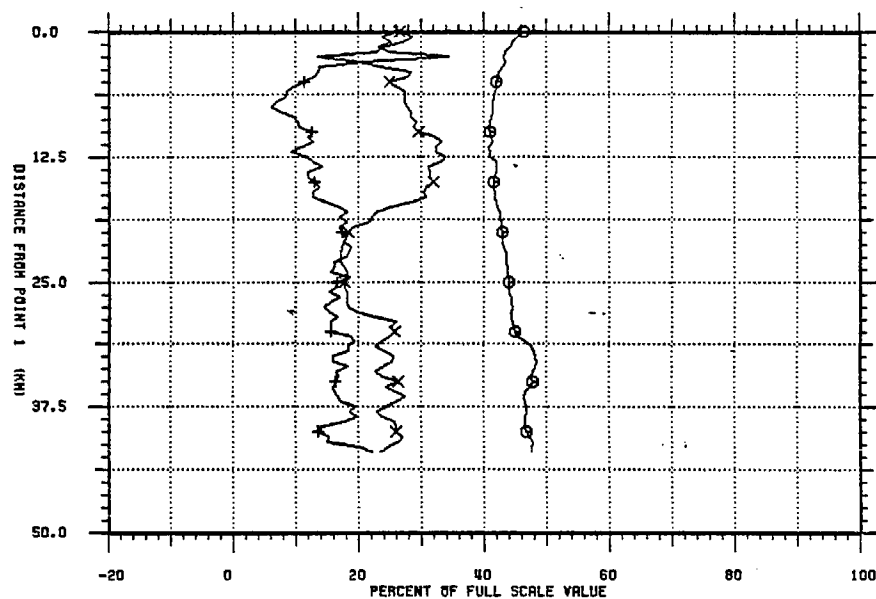
Fig. 4.6.14

SANBOX STUDY

TRAVERSE FROM POINT 1 TO POINT 12 (122 M MSL)

TAPE/PASS: 185/20 DATE: 10/1 /80

TIME: 1842 TO 1856 (PDT)



821201.0
17:01:58

AIRCRAFT TRAVERSE - VENTURA TO SANTA BARBARA

(1842 PDT)

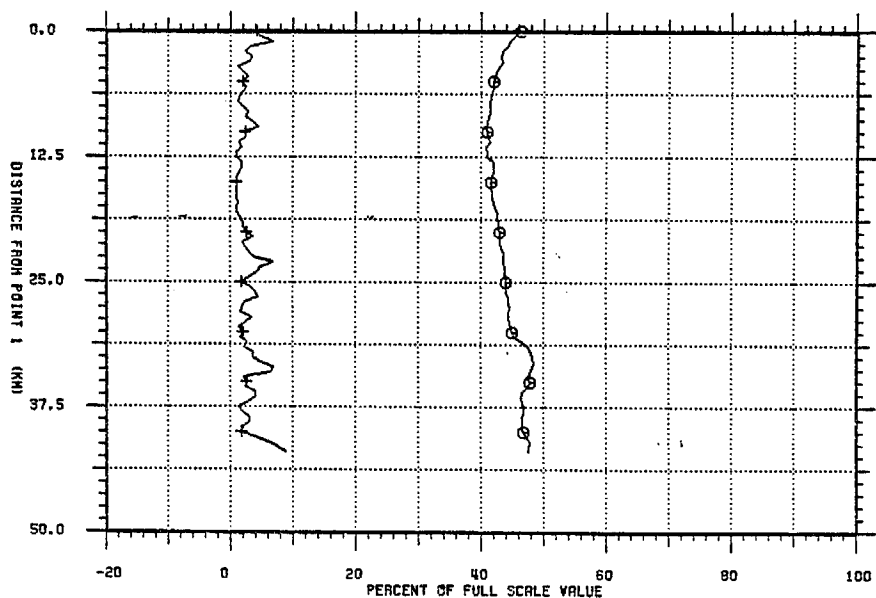
October 1, 1980

SANBOX STUDY

TRAVERSE FROM POINT 1 TO POINT 12 (122 M MSL)

TAPE/PASS: 185/20 DATE: 10/1 /80

TIME: 1842 TO 1856 (PDT)



821201.0
17:01:58

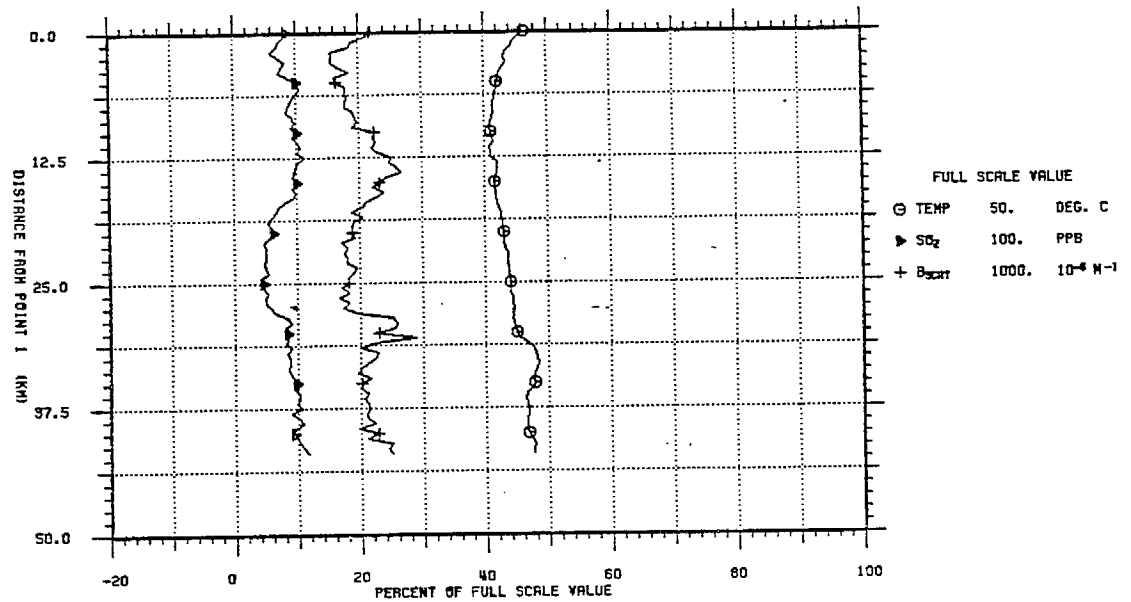
Fig. 4.6.15a

SANBOX STUDY

TRAVERSE FROM POINT 1 TO POINT 12 (122 M MSL)

TAPE/PASS: 185/20 DATE: 10/1 /80

TIME: 1842 TO 1856 (PDT)



821201.0
17:01:58

AIRCRAFT TRAVERSE - VENTURA TO SANTA BARBARA

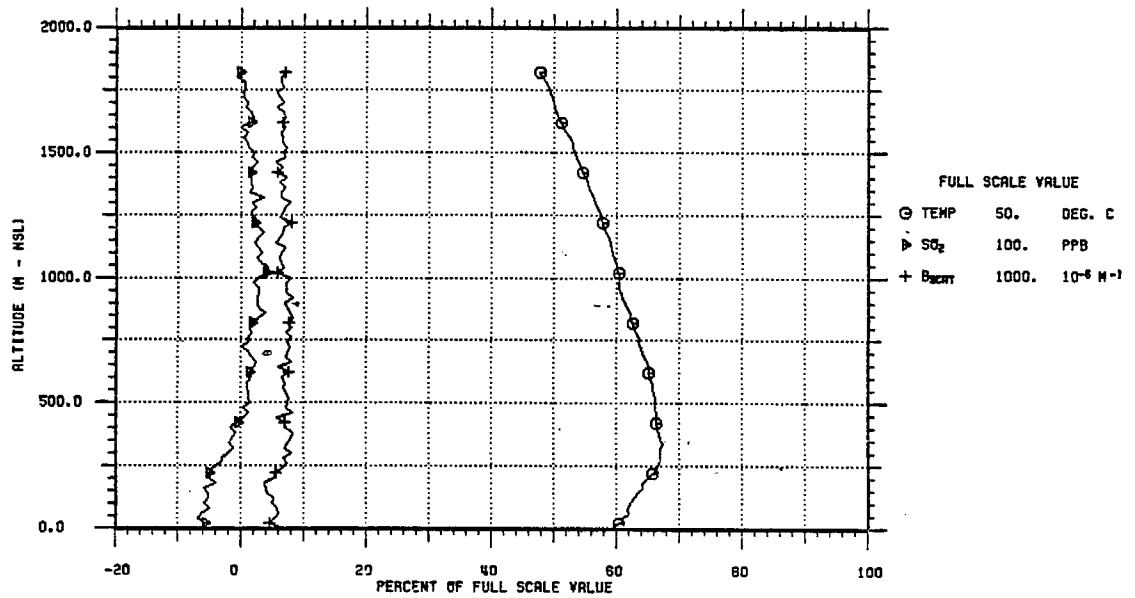
(1842 PDT)

October 1, 1980

Fig. 4.6.15b

SANBOX STUDY
SPIRAL AT POINT 12

TAPE/PASS: 185/21 DATE: 10/1 /80
TIME: 1857 TO 1911 (PDT)



821201.0
17:01:58

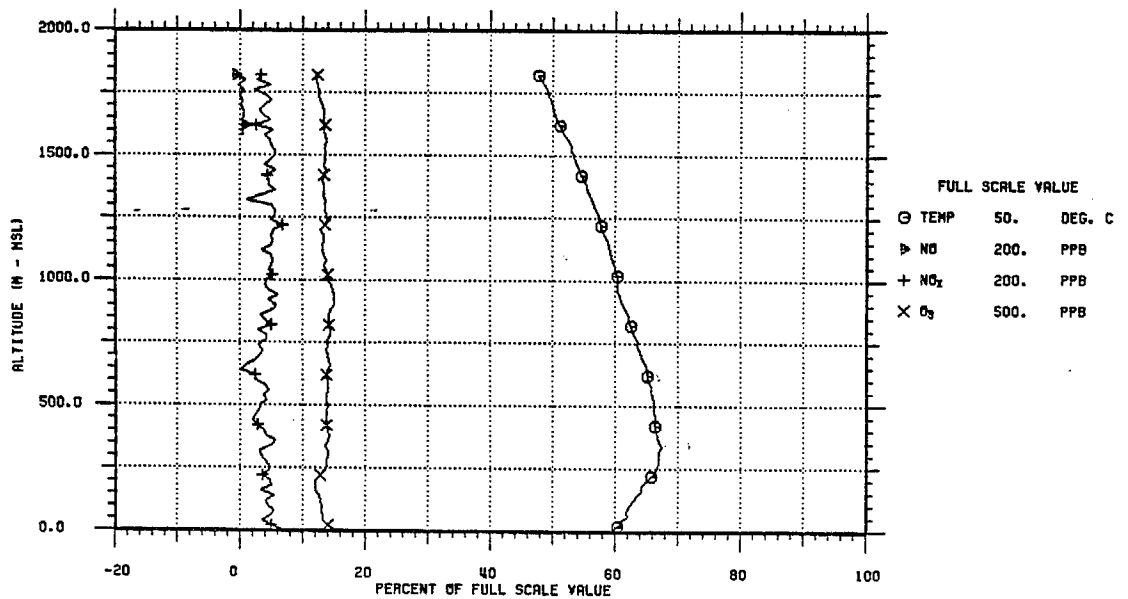
AIRCRAFT SOUNDING OFF SANTA BARBARA

(1857 PDT)

October 1, 1980

SANBOX STUDY
SPIRAL AT POINT 12

TAPE/PASS: 185/21 DATE: 10/1 /80
TIME: 1857 TO 1911 (PDT)



821201.0
17:01:58

Fig. 4.6.16

4.6.6 Tracer Results - Test 5

Release Location: near Platform Grace
Date: October 1, 1980
Time: 06-11 PDT
Release Rate: 5.8 g SF₆ per sec

Surface winds during the release period at Platform Grace are shown in Table 4.6.5.

Table 4.6.5

Surface Winds - Platform Grace
October 1, 1980

Time	Wind Direction	Wind Speed
06 PDT	115°	2.8 m/s
07	156	2.7
08	151	2.1
09	70	0.9
10	117	0.6
11	154	0.6

Wind directions were from the southeast during the release period. Wind velocities were light, decreasing to less than 1 m/s for the final few hours of the release.

Streamline charts for October 1 are given in Figures 4.6.17 and 4.6.18. The wind flow in the channel was predominantly from the east and southeast through 08 and 12 PST. By 12 PST the flow had shifted to westerly in the extreme western end of the channel and evidence of a seabreeze flow along the immediate Ventura coast was becoming apparent. By 16 PST the flow throughout the entire channel had shifted to a west to southwest direction.

These variations in the streamline flows result in a complex set of tracer trajectories as indicated in Figure 4.6.19. The early portion of the tracer release moved to the northwest where SF₆ was observed in the Goleta area. A later portion moved to the north-northwest into Carpinteria and thence down the coast into the coastal plain to the east of Ventura. The later portion of the release was influenced by the shift to a westerly flow and moved northeastward into the coastal valleys, particularly Ojai. In the southern portion of Ventura County the tracer material arrived after the seabreeze had ended so that the interior valleys were not substantially influenced.

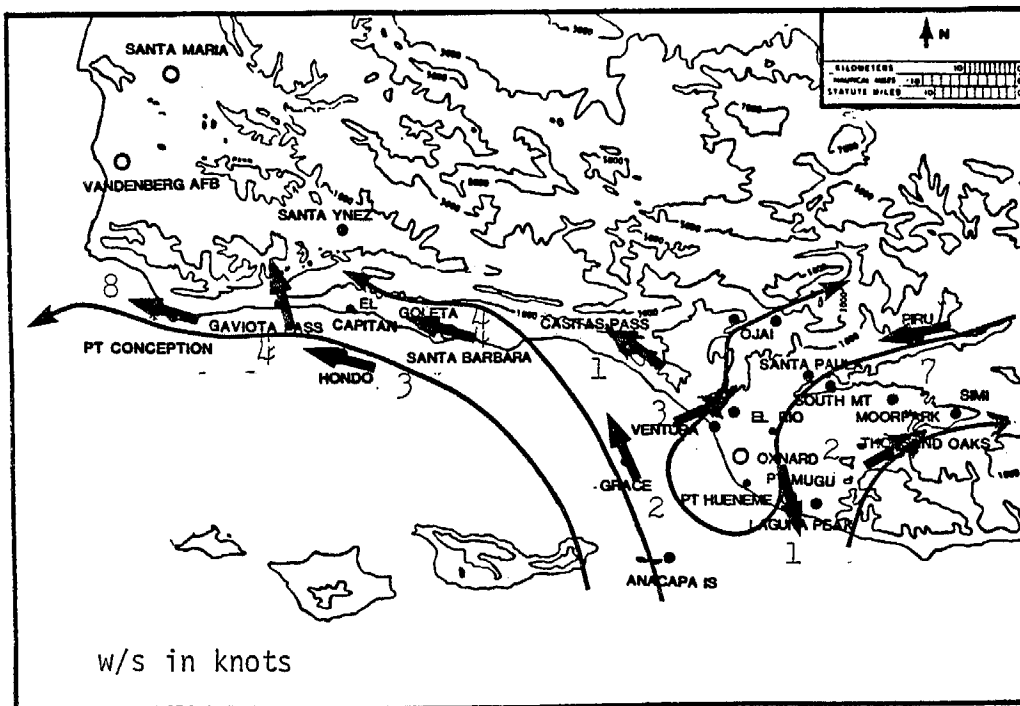
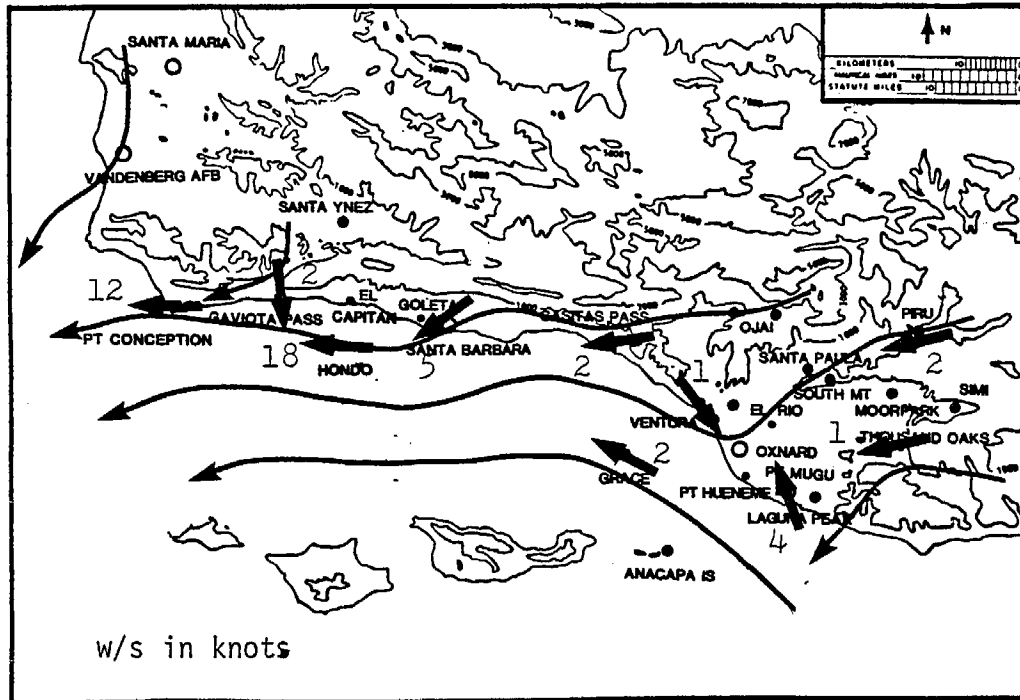
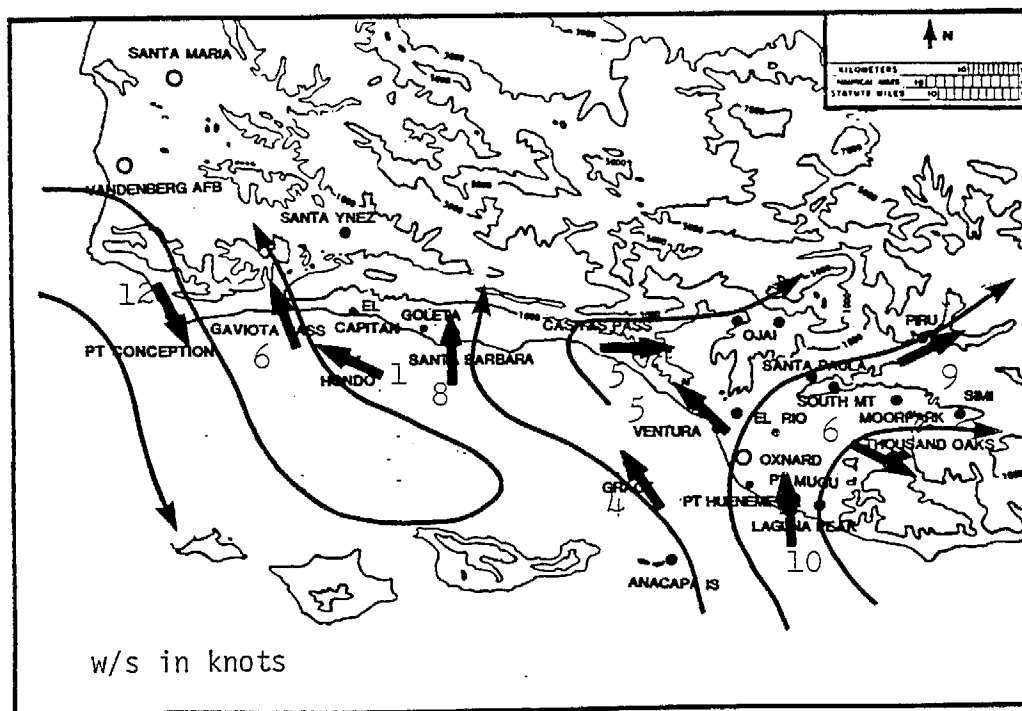
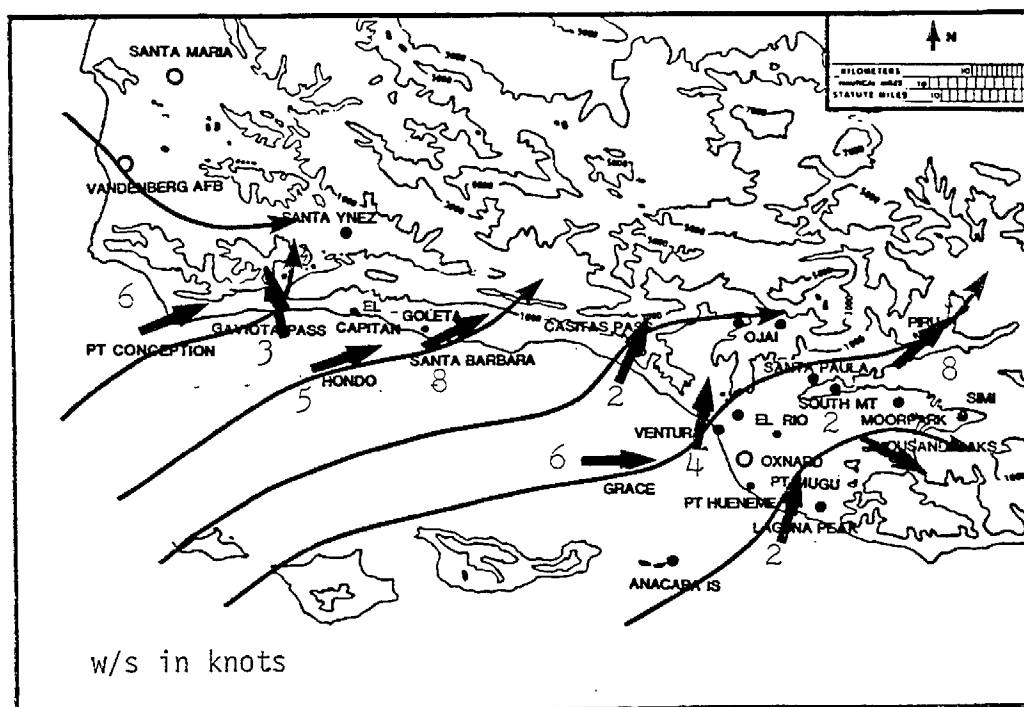


Fig. 4.6.17 STREAMLINE CHARTS - October 1, 1980



12 PST



16 PST

Fig. 4.6.18 STREAMLINE CHARTS - October 1, 1980

Figure 4.6.20 gives the hourly histories of ozone and SF₆ for Piru and Ojai on October 1. The ozone peak at Ojai was 9 pphm, lasting from 11-16 PST. The principal SF₆ concentrations commenced at 16 PST and continued through 06 PST on the following day. The tracer concentrations were separated from the ozone concentrations, therefore, by a few hours. The ozone peak at Piru occurred at 14 PST but there was no significant tracer until a minor peak arrived at 24 PST.

Xu/Q values have been calculated for October 1 and are shown in Table 4.6.6.

Table 4.6.6
Calculated Xu/Q Values
Test 5 - October 1, 1980

Wind Speed	Location	Time	Type of Sample	Distance	Xu/Q ($\times 10^{-6}$)
1.6 m/s	Carpinteria	12 PDT	H	30 km	0.57 m ⁻²
	Carpinteria	18	H	30	1.11
	Ojai	17	H	35	0.06
	Oxnard	18	H	30	0.13
	Piru	01	H	90	0.02
	Santa Barbara	14	H	35	2.31
	Santa Paula	02	H	70	0.06
	Thousand Oaks	24	H	90	0.05
	Ventura	23	H	50	0.03
	Carpinteria	15	A	30	21.1
	SE Santa Barbara	16	A	30	5.49
	Ventura	17	A	20	6.24
	off Carpinteria	18	A/C	20	1.44
	off Carpinteria	17	A/C	20	1.45

These values have been plotted in Figure 4.6.21 for comparison with Pasquill stability estimates. The samples obtained by the automobile traverses corresponded to categories E-F or G. The remainder of the samples, including all of the hourly data showed a maximum value corresponding to an E category and the balance of the data indicated a D or less category. Due to the complexity of the tracer trajectories the far downwind hourly samples involved considerable meandering and dilutions.

Total tracer dosages were calculated for the hourly sampling stations for the 24-hour period with maximum tracer impact. These dosages are given in Table 4.6.7.

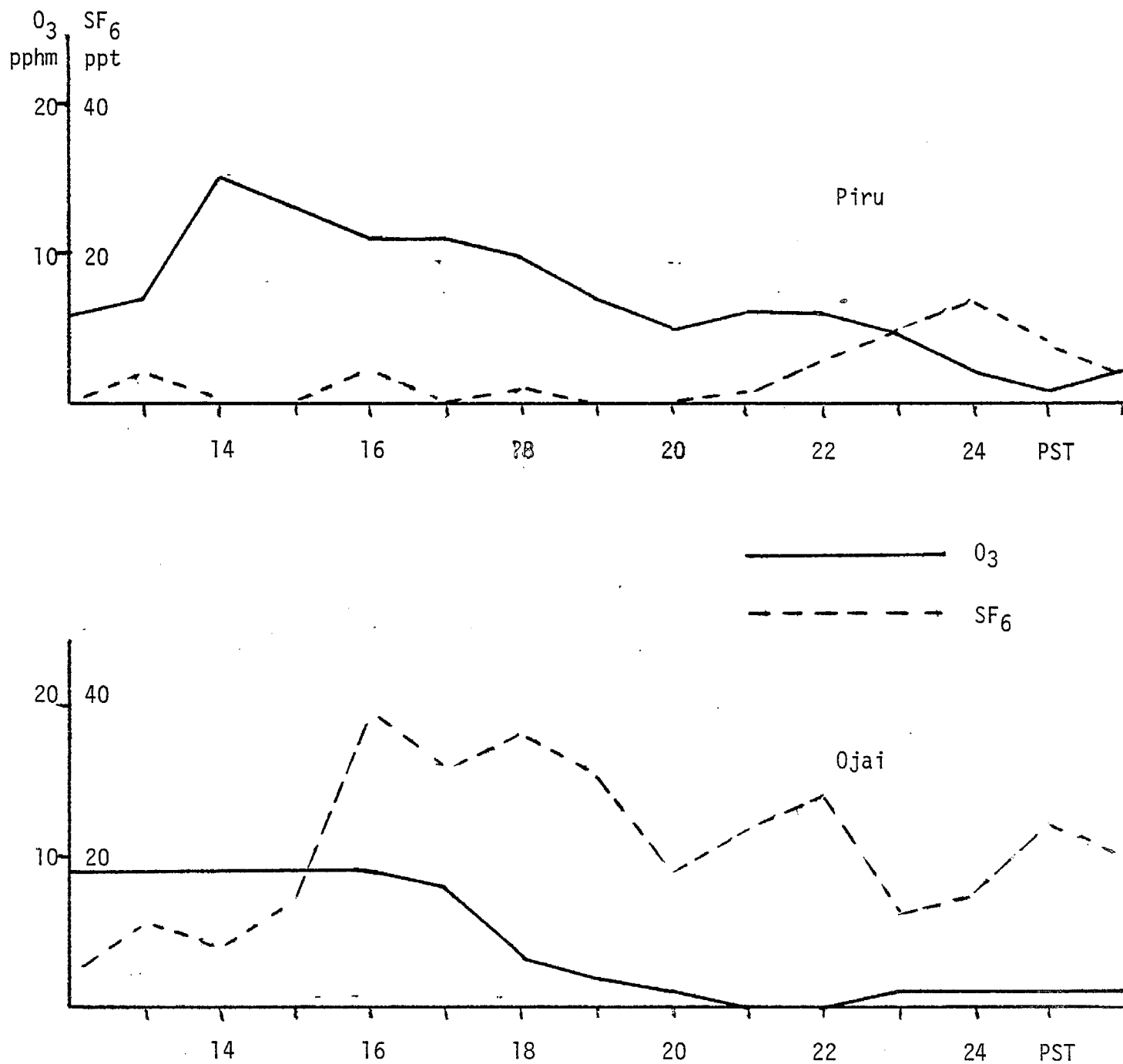


Fig. 4.6.20 HOURLY CONCENTRATIONS OF OZONE AND SF₆ - October 1, 1980

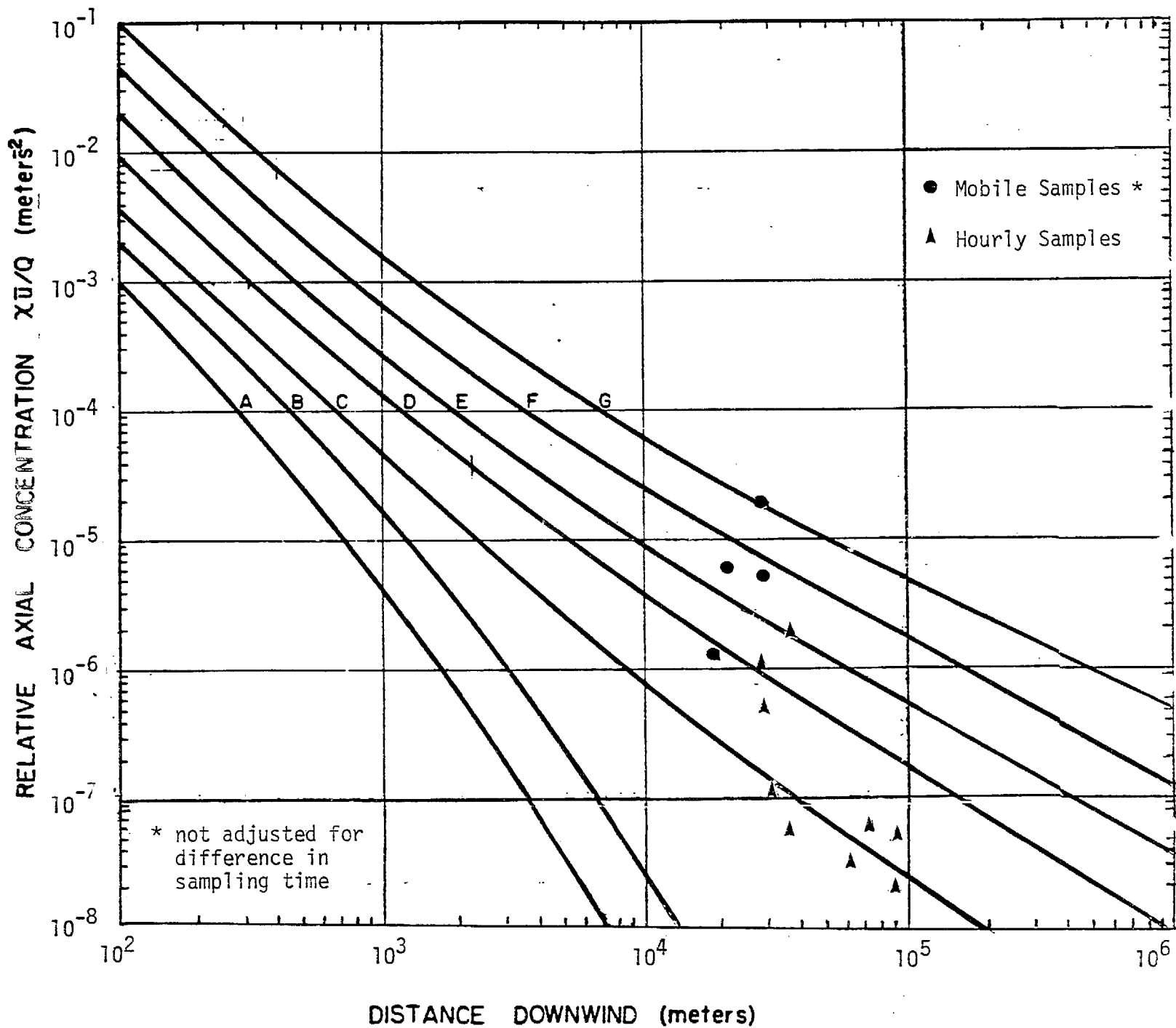


Fig. 4.6.21 $\bar{X}\bar{U}/Q$ VALUES - Test 5
 October 1, 1980

Table 4.6.7

Total SF₆ Dosages
Test 5 - October 1, 1980

Location	Total Dosage	Number of Hours \geq 10 ppt
Santa Barbara	4281 ppt	21
Carpinteria	2674	19
Ventura	71	5
Ojai	364	16
Santa Paula	246	13
Piru	24	2
Oxnard	216	10
Camarillo	301	12
Thousand Oaks	158	11
Simi	37	3

Principal short-term tracer impacts were in the Santa Barbara and Carpinteria areas, associated with the initial trajectory toward the northwest. The total dosage impact was also greatest in this area with 21 and 19 hours of concentrations \geq 10 ppt observed at Santa Barbara and Carpinteria, respectively. Over half of the total dosages shown in the table for Santa Barbara and Carpinteria, however, occurred in 2-3 hours of direct plume impact.

The final BLM release was made on September 29 and it is not likely that substantial carry-over occurred into October 1.

Automobile traverses were made on October 2 to evaluate the carry-over from the October 1 release. Figure 4.6.22 shows the routes and the areas where concentrations of at least 10 ppt were observed. A number of SF₆ concentrations of 30-50 ppt were observed during the traverses, principally in the coastal plain of Ventura County. As indicated in the figure widespread occurrences of at least 10 ppt were found.

4.7 Test 6 3 October 1980 - Release from 4 mi Southwest of Port Hueneme
(0045-0545 PDT)

4.7.1 General Meteorology

The large high pressure area in the Northwest had settled into Idaho and western Montana by October 3 but still dominated the weather in the western part of the country. As the pressure ridge moved to the east the offshore flow in southern California diminished but temperatures aloft remained quite warm. Low overcast and fog prevailed in the channel and along the coast throughout the day. Visibilities were 1 mile or less in fog at Santa Barbara and Pt. Mugu for most of the day.

Significant meteorological parameters for October 3 are given in Table 4.7.1.

Table 4.7.1

Meteorological Parameters

October 3, 1980

850 mb Temperature (Vandenberg AFB)	27°C
Pressure Gradients (07 PST)	
LAX-Bakersfield	0.1mb
Santa Barbara-Daggett	0.1
Inversion Base (15 PST)	
Pt. Mugu	109m
Maximum Surface Temperatures	
Thousand Oaks	---
Piru	85°F
Santa Barbara	67

Temperatures aloft were very warm as evidenced by the 27°C reading at Vandenberg AFB at 03 PST. This was the warmest temperature recorded during September - October 1980.

Morning pressure gradients were quite flat in all coast to inland directions. Surface maximum temperatures decreased by 20°F or more from the high readings of October 1 as a result of the movement of the high pressure ridge to the east and the consequent return of a marine air influence. The 03 PST wind velocity at 5000 ft. at Vandenberg AFB was only one knot, suggesting the end of any important offshore flow although temperatures remained warm aloft.

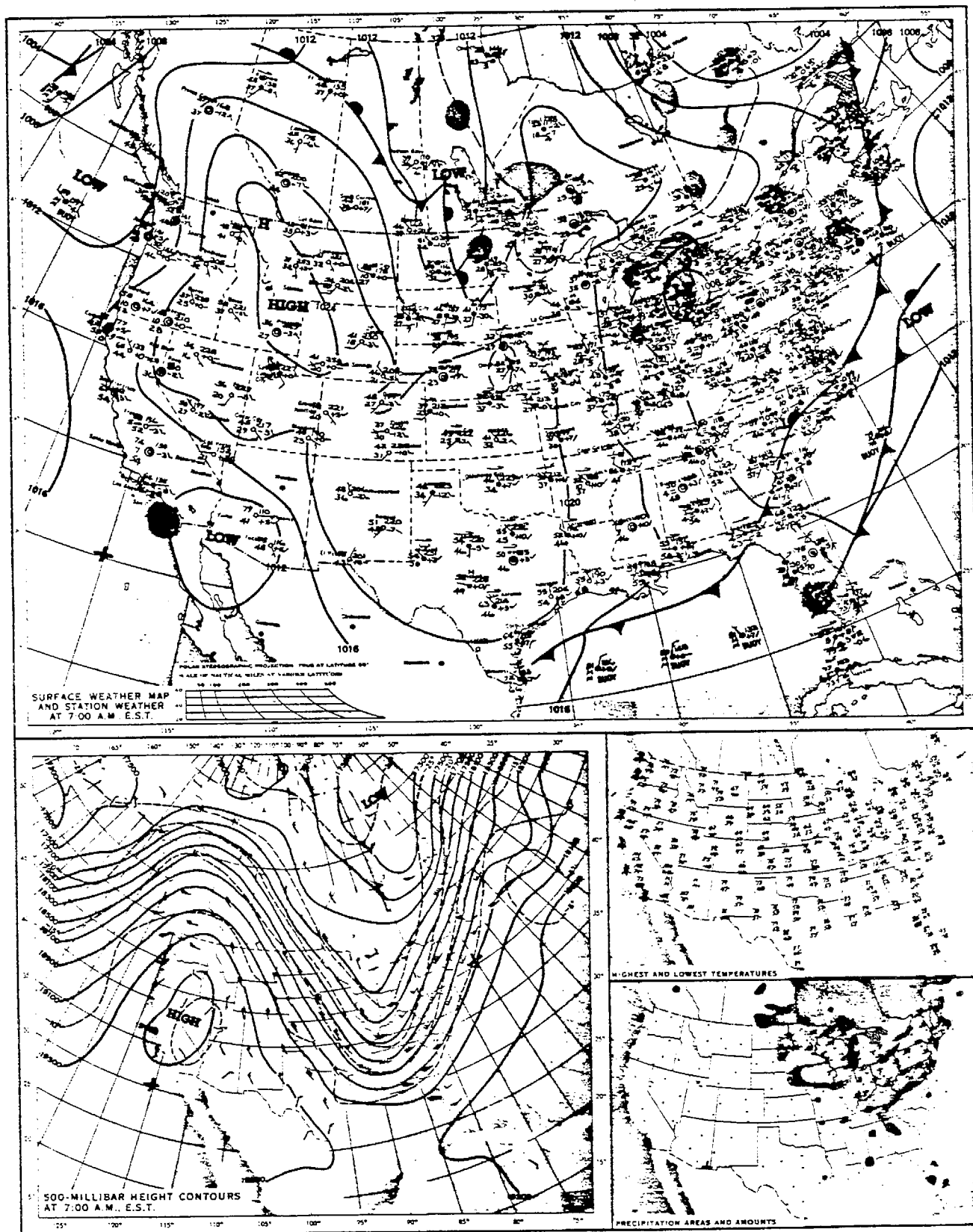


Fig. 4.7.1 WEATHER MAP - October 3, 1980

4.7.2 Transport Winds

Table 4.7.2 shows the surface transport winds at several locations in the area. At Pt. Conception the winds were generally from the southeast except for a few hours of northwesterly winds in the late afternoon.

Winds at Hondo and Santa Barbara were east to southeast during most of the day with a brief occurrence of southwesterly during the late afternoon (similar to Pt. Conception). Wind velocities at Platform Grace were very light throughout the day. Southeasterly winds prevailed until evening when the direction became more westerly. The seabreeze flow at Ventura was evident for a brief period during the afternoon but with very light velocities. Otherwise, wind directions were mainly from the southeast.

Table 4.7.2

Transport Winds - Test 6

October 3, 1980

Time PST	Pt. Conception		Hondo		Santa Barbara		Grace		Ventura Surfers Point	
	w/d	w/s	w/d	w/s	w/d	w/s	w/d	w/s	w/d	w/s
06	107°	6.7 m/s	098°	4.5 m/s	030°	2.6 m/s	094°	0.8 m/s	135°	2.4 m/s
08	119	7.9	086	3.6	060°	2.1	108	1.3	90	0.6
10	161	3.1	108	3.6	120	2.6	141	1.8	145	0.7
12	152	2.6	120	1.8	130	4.1	134	1.8	220	1.4
14	217	2.2	129	0.9	160	3.6	164	0.7	225	1.9
16	281	3.3	219	0.4	200	3.6	210	2.4	210	1.8
18	300	3.3	263	0.9	250	2.1	202	0.3	160	1.1
20	177	0.7	263	0.9	160	2.1	323	1.0	175	1.1
22	133	3.2	255	0.4		Calm	205	0.3	125	1.4
24	143	4.3	120	0.4	130	2.1	230	0.4	090	2.4

4.7.3 Mixing Heights

Observed mixing heights for October 3 are given in Table 4.7.3. All inland area aircraft soundings showed an upper layer to 800-1000 m above ground level. With the exception of the San Fernando Valley location there was also a shallow marine layer by mid to late afternoon. The upper layer was embedded in winds from the southwest. The layer aloft observed at 1100 m-msl at the west end of the San Fernando Valley represents transport from the west in contrast to the September 28 and October 1 cases.

Table 4.7.3

Mixing Heights*

October 3, 1980

1. Measured by Sampling Aircraft

Time	Location	Height
1349 PDT	Santa Ynez Airport (upper layer to 800m)	250m
1444	Near Ojai (Upper layer to 800m)	200
1523	Piru (Upper layer to 850m)	200
1542	W end San Fernando Valley (Upper layer to 800m)	650
1628	Santa Susana Airport (Upper layer to 1000m)	200

2. Measurements by Pibals

Time	Santa Ynez	Ojai	Simi
09 PDT	53m	159m	365m
11	263	159	159
13	159	662	263
15	365	662	365
17	466	466	263
19	53	263	53

3. Measured by MRI Acoustic Sounder

Santa Paula Airport	Height
11 PDT	90m
13	180
15	200
17	180
19	100
21	<40

* Heights are above surface

4.7.4 Regional Ozone Concentrations

Maximum ozone concentrations for a number of locations are shown in Table 4.7.4. In keeping with the highest temperature observed during the field program at 850 mb, surface ozone concentrations were also the highest recorded. A peak value of 19 pphm was observed at Piru and Moorpark. All of the stations listed in the table including Pt. Conception and Platform Grace experienced maximum hourly ozone concentrations exceeding the state standard. Background ozone concentrations, as measured by the aircraft, averaged 5-6 pphm.

Aircraft soundings were made near Ojai, Piru and Santa Susana Airport (Simi) at 1444, 1523 and 1628 PDT, respectively. These soundings are shown in Section 4.7.5 and discussed in greater detail. Each sounding showed a low, marine layer which contained much greater concentrations than observed in the layers aloft. Comparison of these soundings with the time histories of surface ozone concentrations (Figure 4.7.2) indicates that all of the peak concentrations at the inland locations occurred within the low-level marine layer.

Ventura and Pt. Hueneme experienced peak surface ozone concentrations of 11 pphm for 4-5 hours beginning at 13 PST. Since the winds were consistently from the southwest during this period, it is suggested that these ozone concentrations were transported from offshore into the coastal zone. This is further indicated by the peak ozone value of 13 pphm which occurred at Platform Grace during the early morning hours.

The unusual observation of 12 pphm ozone at Pt. Conception also occurred in the early morning under southeasterly wind conditions. This evidence of widespread, high values of ozone offshore and in the coastal areas suggests that the episode conditions which had occurred for the past several days had led to a gradual increase in ozone concentrations throughout the offshore and near coastal regions.

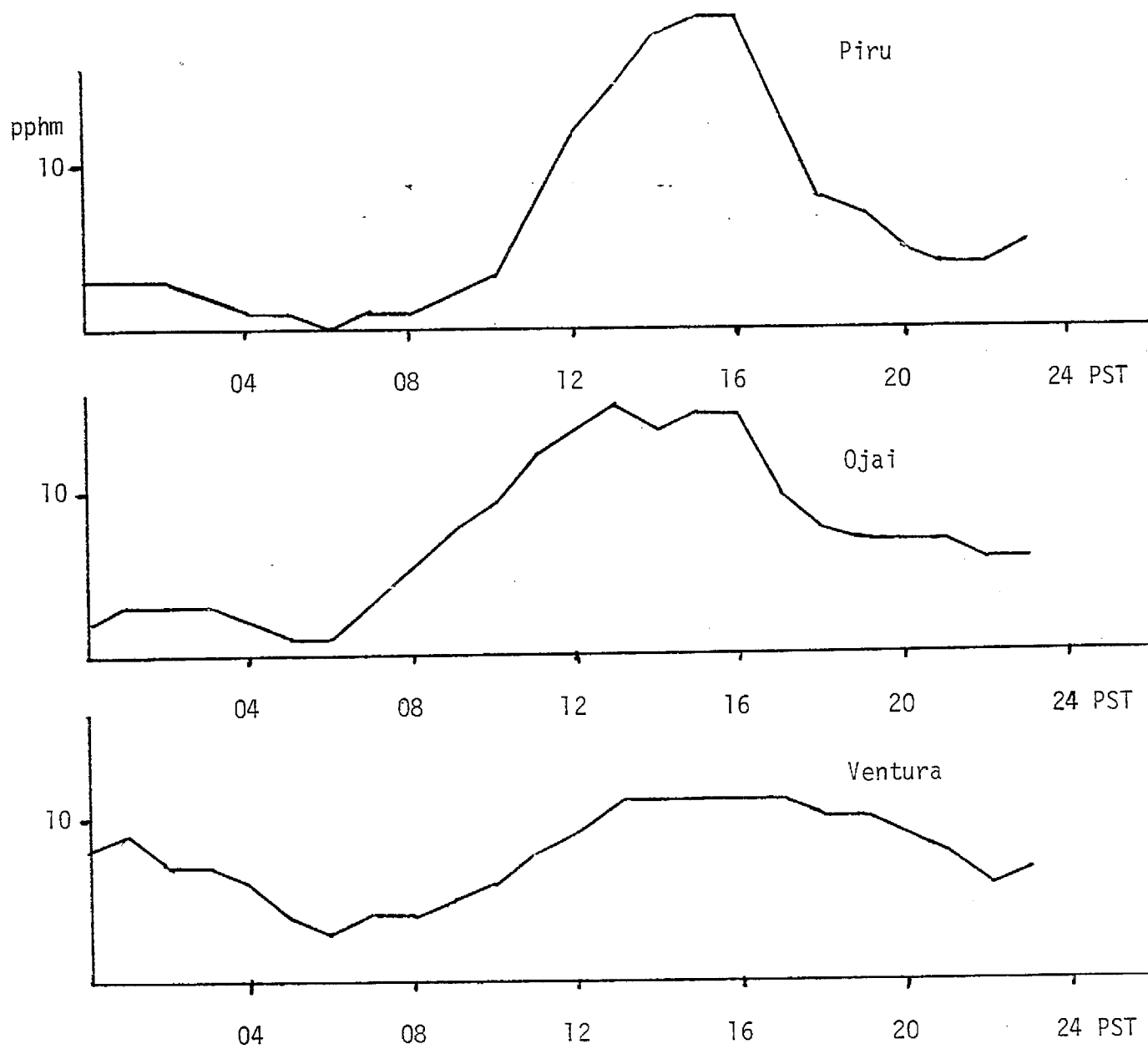


Fig. 4.7.2a HOURLY OZONE CONCENTRATIONS - October 3, 1980

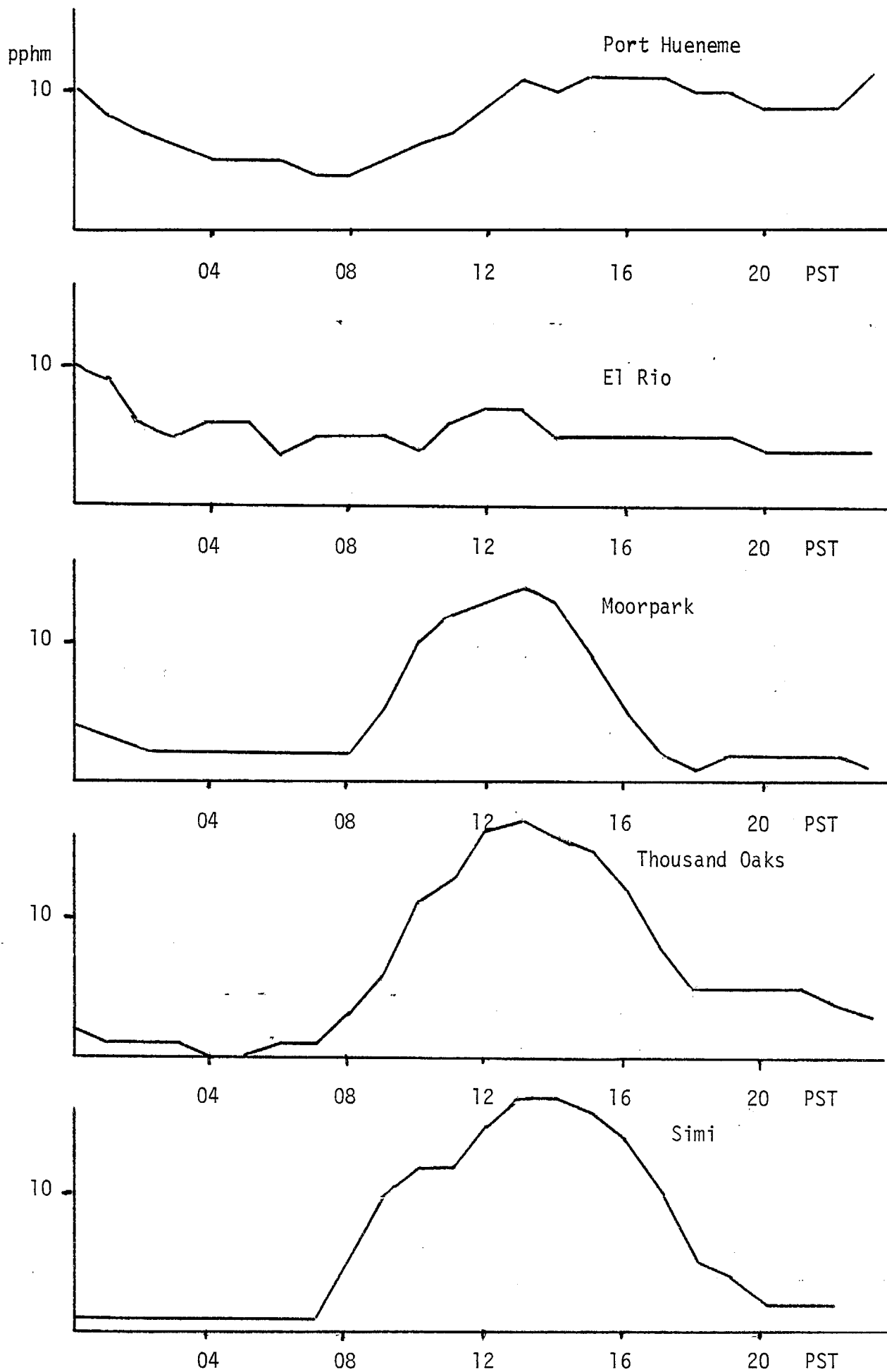


Fig. 4.7.2b HOURLY OZONE CONCENTRATIONS - October 3, 1980

Table 4.7.4

Regional Maximum Ozone Concentrations (pphm)

October 3, 1980

Location	Max O ₃	Time of Max (PST)	Wind Direction at Time of Max	Time of Max Temp (PST)
Pt. Conception	12	08	119°	11-12
Goleta	11	14	160	13-14
Platform Hondo	M			
Ojai	15	13,15-16	290	14
Piru	19	15-16	225	14
Simi Valley	17	13-14	280	10-14
South Mt.	18	21	135	11
Thousand Oaks	17	13	M	M
Moorpark	19	13	M	M
El Rio	12	12-13	M	M
Ventura	11	13-17	210	12
Pt. Hueneme	11	13,15-17,23	220*	14*
Platform Grace	13	03	100	13
Background	5-6			

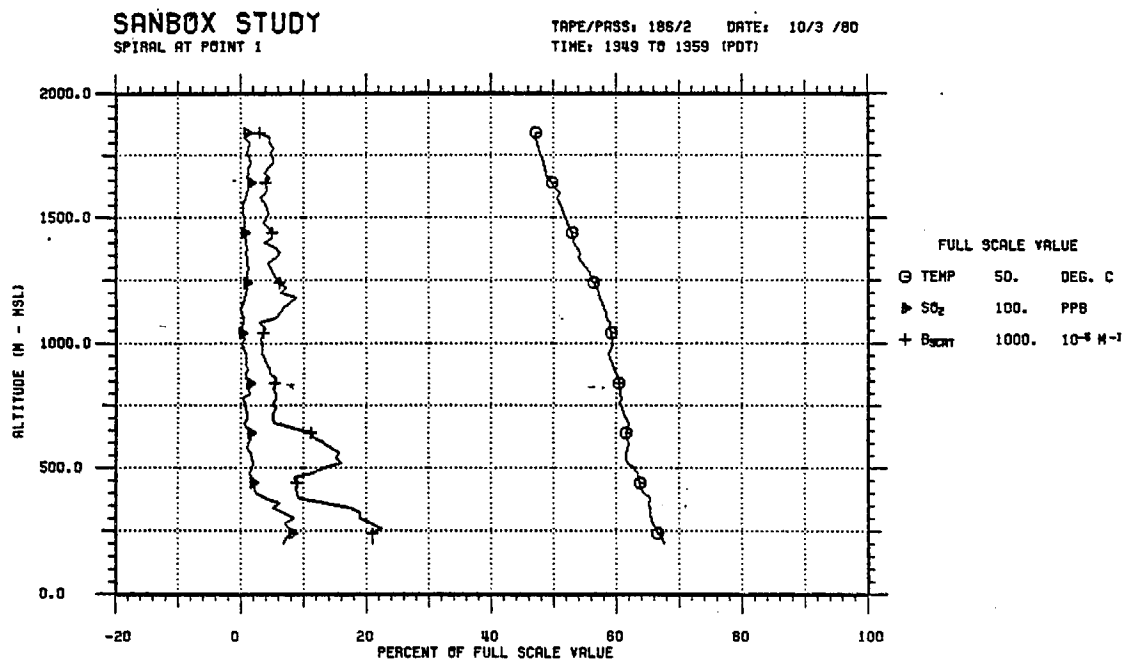
*Pt. Mugu

4.7.5 Aircraft Sampling

Air quality aircraft sampling on October 3 was carried out primarily in the inland valleys from the coast to Ojai, Piru and Simi. A sounding was also made at Santa Ynez Airport.

The sounding at Santa Ynez Airport at 1349 PDT is shown in Figure 4.7.3. Two slightly stable layers are indicated in the temperature profile (at 500 m-msl and 950 m-msl). The surface-based mixing layer extended to 500 m-msl. Peak ozone level was 12 pphm in this layer with west-southwest winds. Another layer of greater than 10 pphm ozone was present between 500 and 950 m-msl, also with west-southwest winds. At higher levels, the wind shifted to northwesterly and the ozone dropped to a background level of 5-6 pphm.

Figure 4.7.4 is a horizontal traverse made at 1431 PDT from west of Carpinteria to Ojai at 457 m-msl. Of particular note is the ozone value of 21 pphm at the beginning of the traverse (over the water). The effects of the surface heating at flight level are indicated by the temperature increase beginning at about 12 km along the traverse. Shortly after this point ozone, NO_x, b_{scat} and SO₂ all increased substantially, peaking prior to the end of the traverse. Peak ozone inland was about 15 pphm which was also the highest hourly reading at Ojai for the day.



AIRCRAFT SOUNDING AT SANTA YNEZ

(1349 PDT)

October 3, 1980

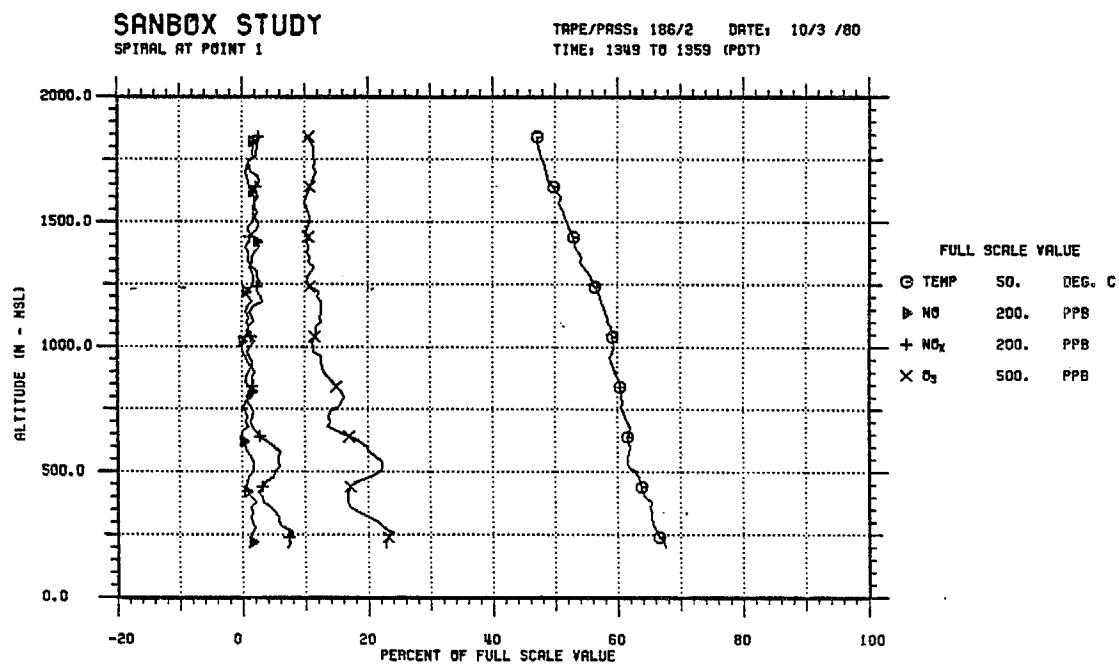


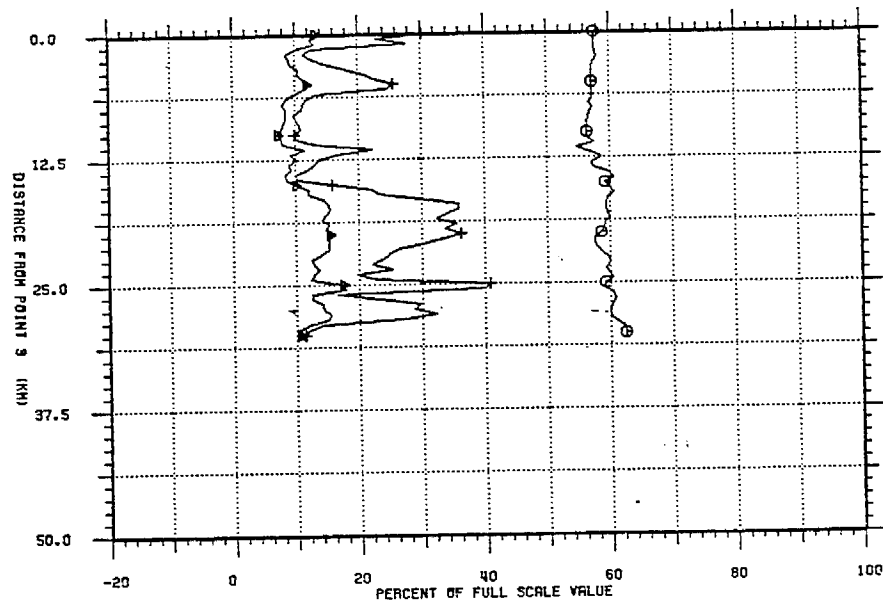
Fig. 4.7.3

SANBOX STUDY

TRAVERSE FROM POINT 3 TO POINT 4 (457 M MSL)

TAPE/PASS: 186/5 DATE: 10/3 /80

TIME: 1431 TO 1440 (PDT)



FULL SCALE VALUE

○ TEMP 50. DEG. C
 ▴ SO₂ 100. PPB
 + B_{scrt} 1000. 10⁻⁶ M⁻³

821201.0
 17:39:48

AIRCRAFT TRAVERSE - CARPINTERIA TO OJAI

(1431 PDT)

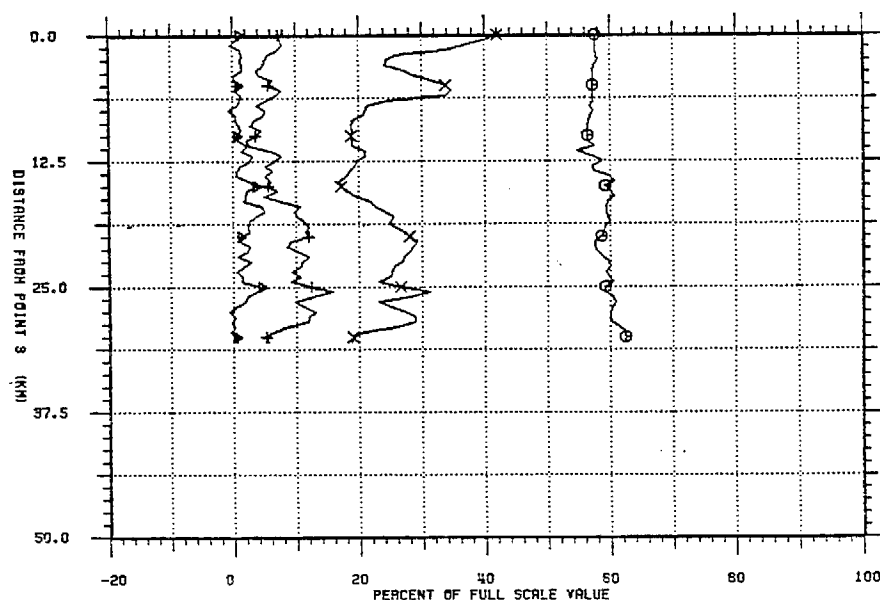
October 3, 1980

SANBOX STUDY

TRAVERSE FROM POINT 3 TO POINT 4 (457 M MSL)

TAPE/PASS: 186/5 DATE: 10/3 /80

TIME: 1431 TO 1440 (PDT)



FULL SCALE VALUE

○ TEMP 50. DEG. C
 ▴ NO 200. PPB
 + NO₂ 200. PPB
 × O₃ 500. PPB

821201.0
 17:39:48

Fig. 4.7.4

A sounding between Lake Casitas and Ojai was made at 1444 PDT and produced the data shown in Figure 4.7.5. The temperature sounding suggests the low-level intrusion of marine air with an inversion base near 300 m-msl. There is evidence in the pollutant profiles as well as the pibal wind structure of a deeper onshore wind layer extending to about 900 m-msl. Highest ozone values of 17 pphm, however, were in the shallow marine layer. Above 1000 m-msl background ozone levels of 5-6 pphm were observed.

Figure 4.7.6 is a horizontal traverse from Ojai to Ventura at 14 PDT at an elevation of 427 m-msl. The major features of the ozone trace are 1) a peak of 15-16 pphm occurring about 2/3 of the way down the valley and 3) a value of 22 pphm at the end of the traverse, the latter being comparable to the near-offshore observation west of Carpinteria at 1431 PDT. The intermediate peak in the valley was observed also in the bscat, NO_x and SO₂ traces.

A horizontal traverse was then flown from Ventura to Piru at 427 m-msl, beginning at 1508 PDT (Figure 4.7.7). During this traverse, high values of SO₂, bscat, NO_x and ozone were observed along the last 2/3 of the traverse. NO values, however, were relatively low. High ozone and bscat values were again seen near the coast (26 pphm ozone maximum) compared to a peak of 23 pphm along the latter part of the traverse. The sharp decrease in pollutant values in the early part of the traverse is the result of the aircraft passing through the top of the pollutant layer and then reentering the layer farther along the flight path.

The spiral in Figure 4.7.8 was flown at Piru at 1523 PDT. A low level inversion existed with a base of 350 m-msl. There was evidence of a deeper layer of mixing to 600 m-msl in the pollutant profiles. West-southwest winds were present below 600 m-msl with southwest winds aloft. The background ozone aloft was 5-6 pphm except for a small peak at 1050 m-msl. As in previous soundings the highest ozone values were present in the low-level marine air (about 150 m deep).

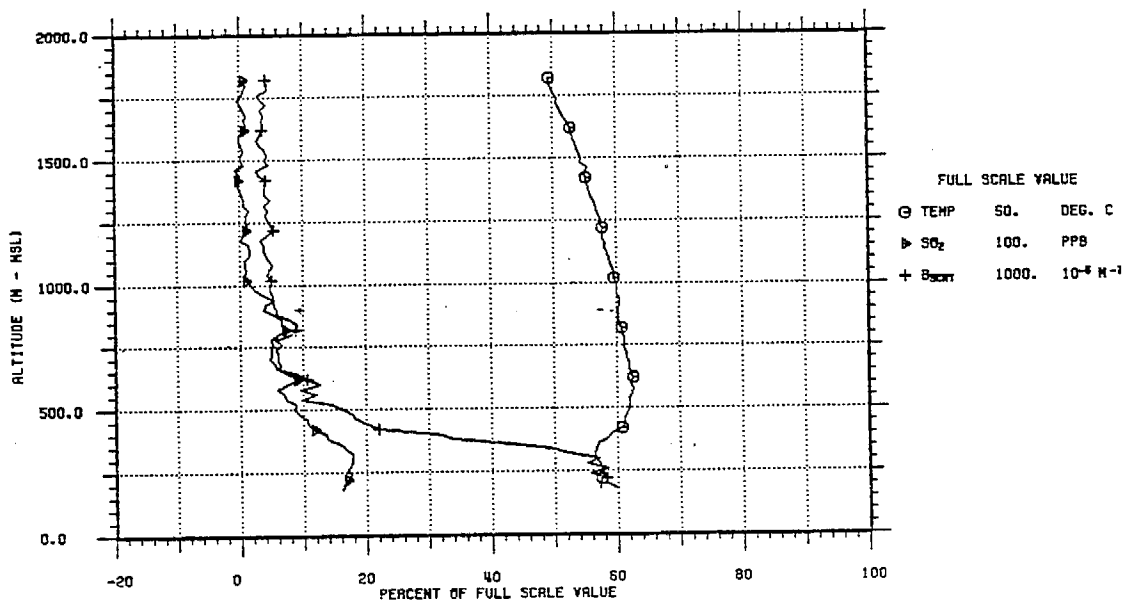
The next spiral gave a comparative sounding (Figure 4.7.9) in the western part of the San Fernando Valley at 1542 PDT. There was a deep mixing layer present (to 950 m-msl) without any indication of marine air intrusion from the west. Peak ozone measured in the mixing layer was 25 pphm at 700 m-msl. Below this level the ozone had presumably been reduced by NO. Background levels of ozone aloft were 5-7 pphm.

A horizontal traverse then began at 1551 PDT from the San Fernando Valley to Ventura through Thousand Oaks. Flight altitude was 701 m-msl. As noted in Figure 4.7.10 there was considerable variation in the pollutant parameters along the traverse. An ozone value of 21 pphm was observed at flight level at the beginning of the traverse. A rapid decrease then occurred at all flight levels, undoubtedly due to the aircraft entering the clean air above the pollutant layer. Farther along the traverse the aircraft reentered the pollutant layer and the pollutant values increased markedly. Since the aircraft did not change altitude with reference to mean sea level it is suggested that the top of the pollutant layer is not always horizontal. Slightly to the west of Thousand Oaks ozone and bscat values

SANBOX STUDY

SPIRAL AT POINT 5

TAPE/PASS: 186/6 DATE: 10/3 /80
TIME: 1444 TO 1455 (PDT)



821201.0
17:39:48

AIRCRAFT SOUNDING NEAR OJAI

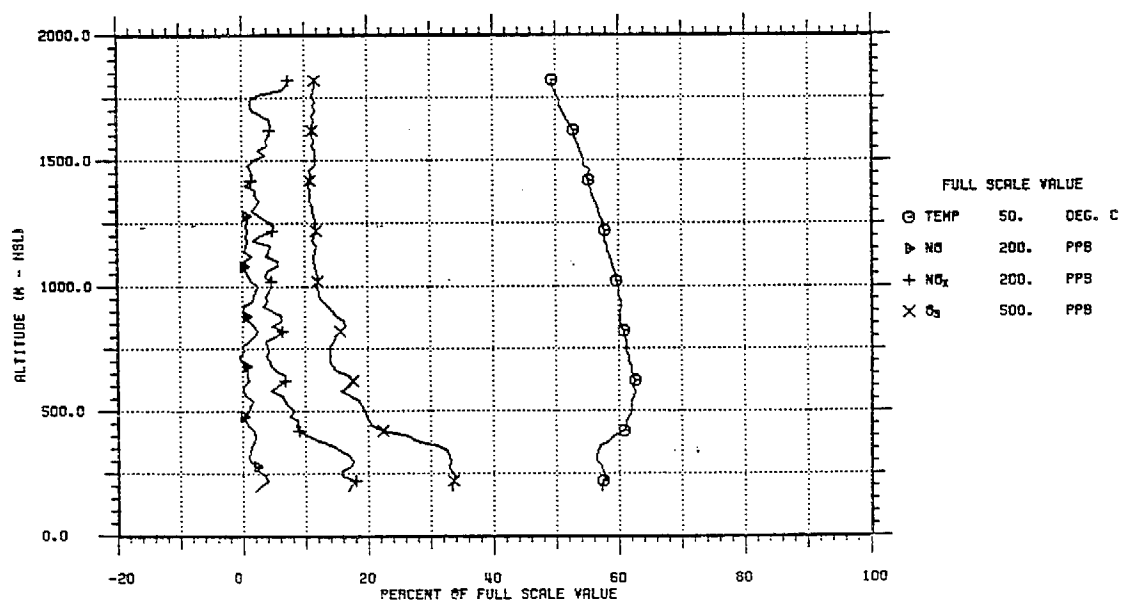
(1444 PDT)

October 3, 1980

SANBOX STUDY

SPIRAL AT POINT 5

TAPE/PASS: 186/6 DATE: 10/3 /80
TIME: 1444 TO 1455 (PDT)



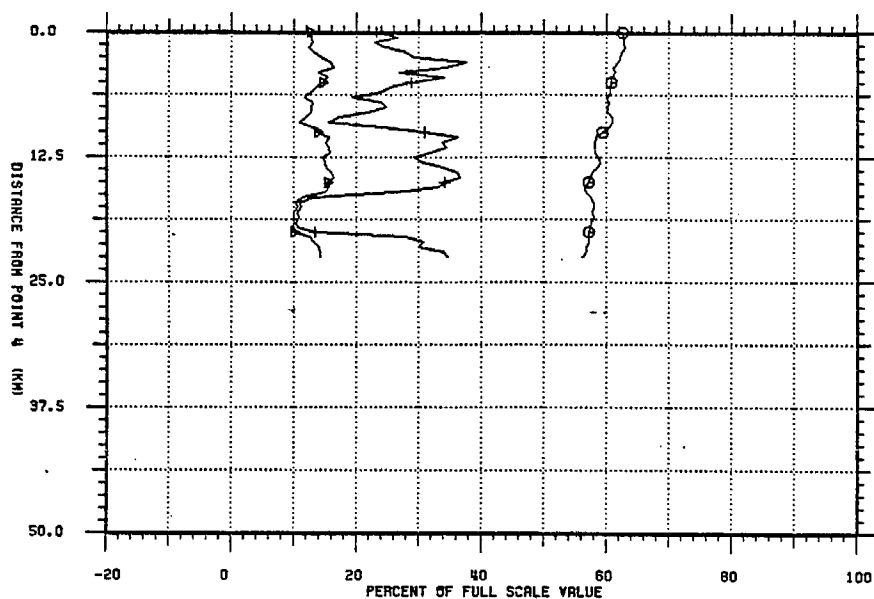
821201.0
17:39:48

Fig. 4.7.5

SANBOX STUDY

TRAVERSE FROM POINT 4 TO POINT 6 (N27 W MSL)

TAPE/PASS: 186/7 DATE: 10/3 /80
TIME: 1458 TO 1508 (PDT)



FULL SCALE VALUE

○ TEMP	50.	DEG. C
▴ SO ₂	100.	PPB
+ B _{SO2}	1000.	10 ⁻⁶ M ⁻¹

821201.0
17:39:48

AIRCRAFT TRAVERSE - OJAI TO VENTURA

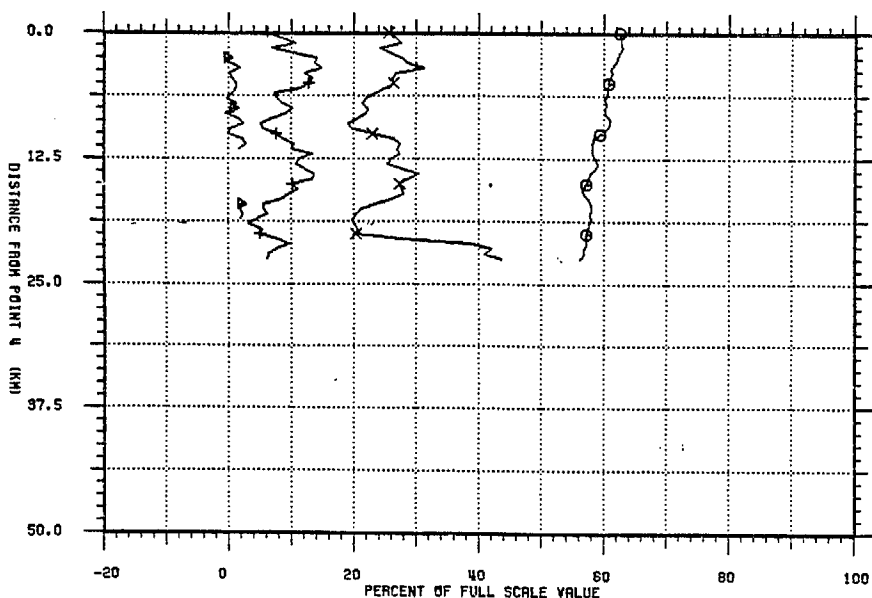
(1458 PDT)

October 3, 1980

SANBOX STUDY

TRAVERSE FROM POINT 4 TO POINT 6 (N27 W MSL)

TAPE/PASS: 186/7 DATE: 10/3 /80
TIME: 1458 TO 1508 (PDT)



FULL SCALE VALUE

○ TEMP	50.	DEG. C
▴ NO	200.	PPB
+ NO _x	200.	PPB
× O ₃	500.	PPB

821201.0
17:39:48

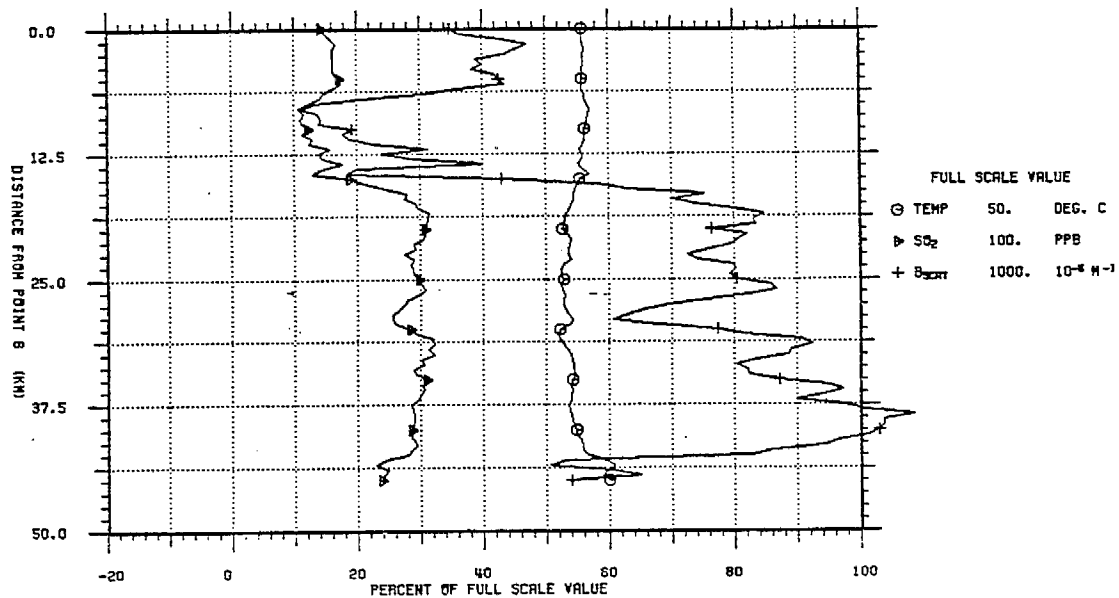
Fig. 4.7.6

SANBOX STUDY

TRAVERSE FROM POINT 6 TO POINT 7 (427 M MSL)

TAPE/PASS: 186/8 DATE: 10/3 /80

TIME: 1508 TO 1522 (PDT)



821201.0
17:39:48

AIRCRAFT TRAVERSE - VENTURA TO PIRU

(1508 PDT)

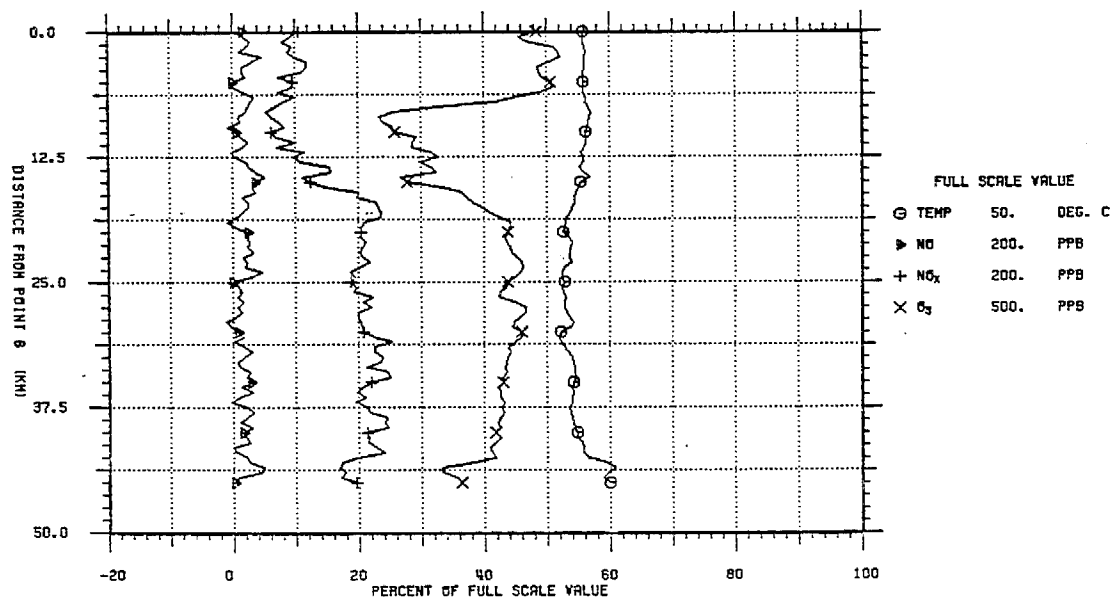
October 3, 1980

SANBOX STUDY

TRAVERSE FROM POINT 6 TO POINT 7 (427 M MSL)

TAPE/PASS: 186/8 DATE: 10/3 /80

TIME: 1508 TO 1522 (PDT)

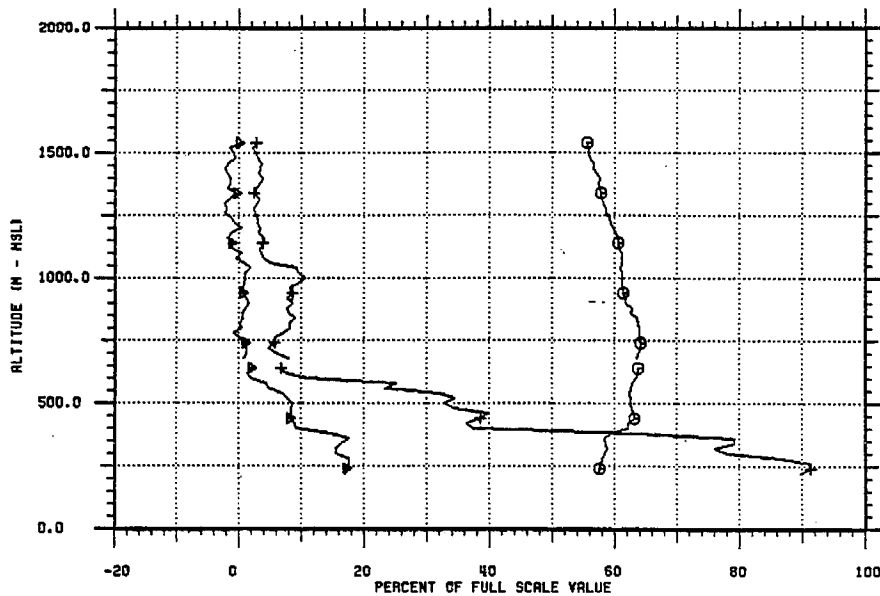


821201.0
17:39:48

Fig. 4.7.7

SANBOX STUDY
SPIRAL AT POINT 7

TAPE/PASS: 186/9 DATE: 10/3 /80
TIME: 1523 TO 1532 (PDT)

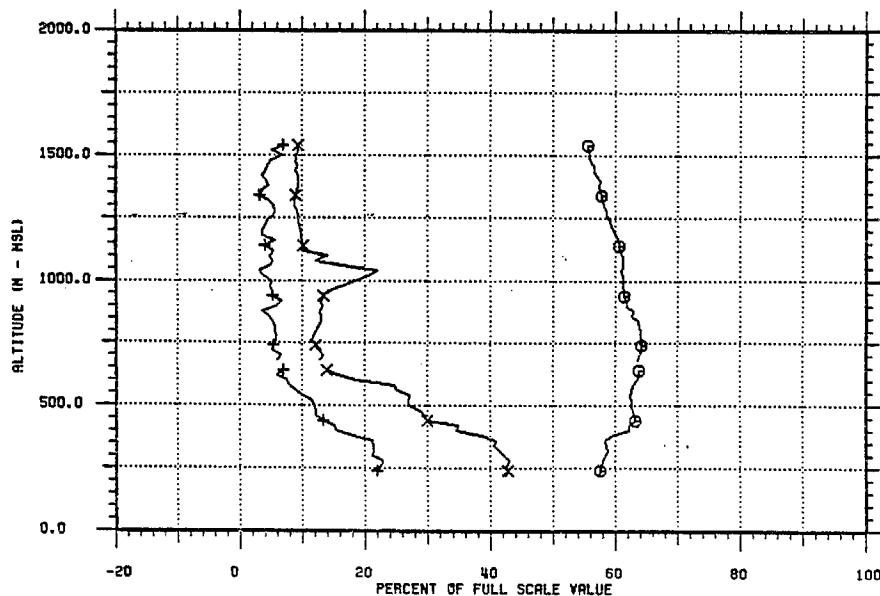


821201.0
17:39:48

AIRCRAFT SOUNDING AT PIRU
(1523 PDT)
October 3, 1980

SANBOX STUDY
SPIRAL AT POINT 7

TAPE/PASS: 186/9 DATE: 10/3 /80
TIME: 1523 TO 1532 (PDT)

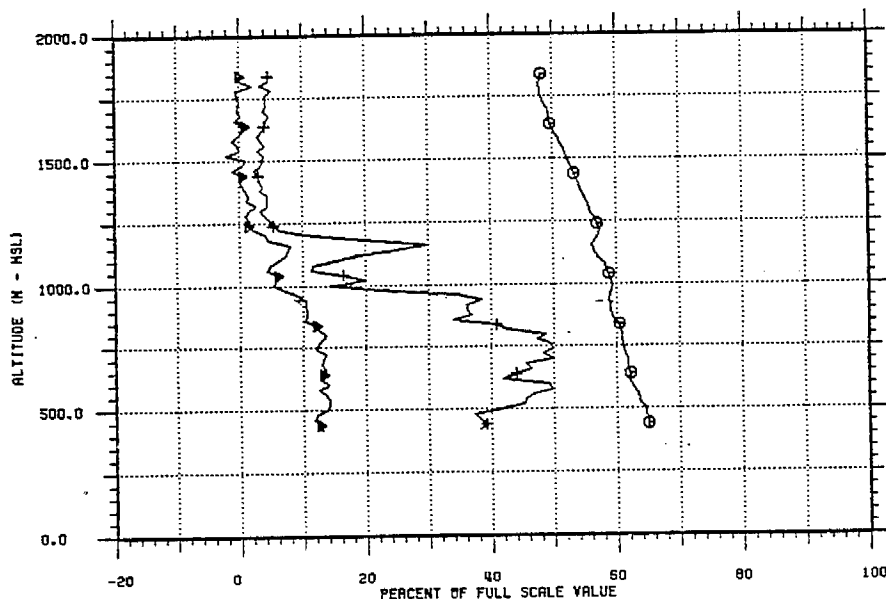


821201.0
17:39:48

Fig. 4.7.8

SANBOX STUDY
SPIRAL AT POINT 8

TAPE/PASS: 186/10 DATE: 10/3 /80
TIME: 1542 TO 1549 (PDT)



821201.0
17:39:48

AIRCRAFT SOUNDING - W SAN FERNANDO VALLEY
(1542 PDT)
October 3, 1980

SANBOX STUDY
SPIRAL AT POINT 8

TAPE/PASS: 186/10 DATE: 10/3 /80
TIME: 1542 TO 1549 (PDT)

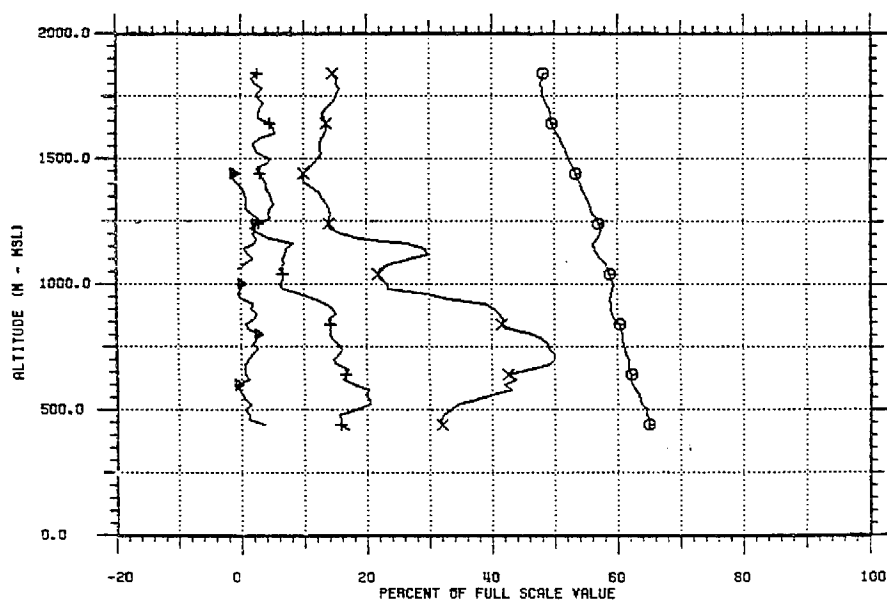
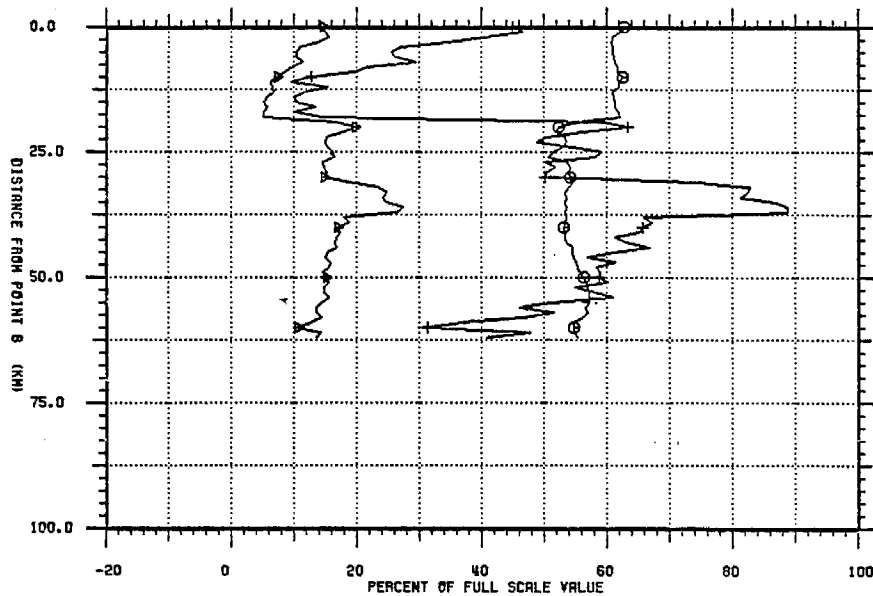


Fig. 4.7.9

821201.0
17:39:48

SANBOX STUDY

TAPE/PASS: 186/11 DATE: 10/3 /80
 TRAVERSE FROM POINT 8 TO POINT 6 (701 M MSL) TIME: 1551 TO 1609 (PDT)



821201.0
 17:39:48

AIRCRAFT TRAVERSE - W SAN FERNANDO VALLEY TO VENTURA

(1551 PDT)

October 3, 1980

SANBOX STUDY

TAPE/PASS: 186/11 DATE: 10/3 /80
 TRAVERSE FROM POINT 8 TO POINT 6 (701 M MSL) TIME: 1551 TO 1609 (PDT)

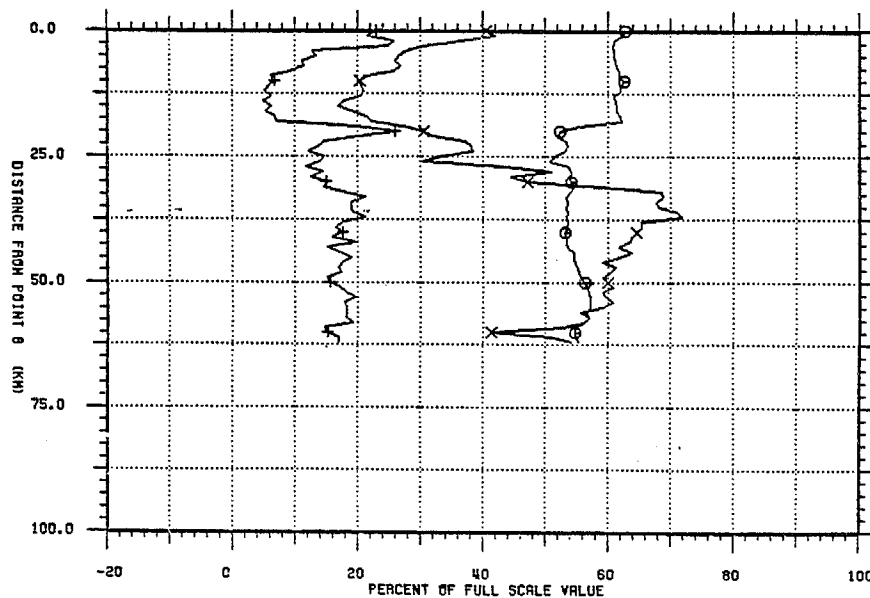


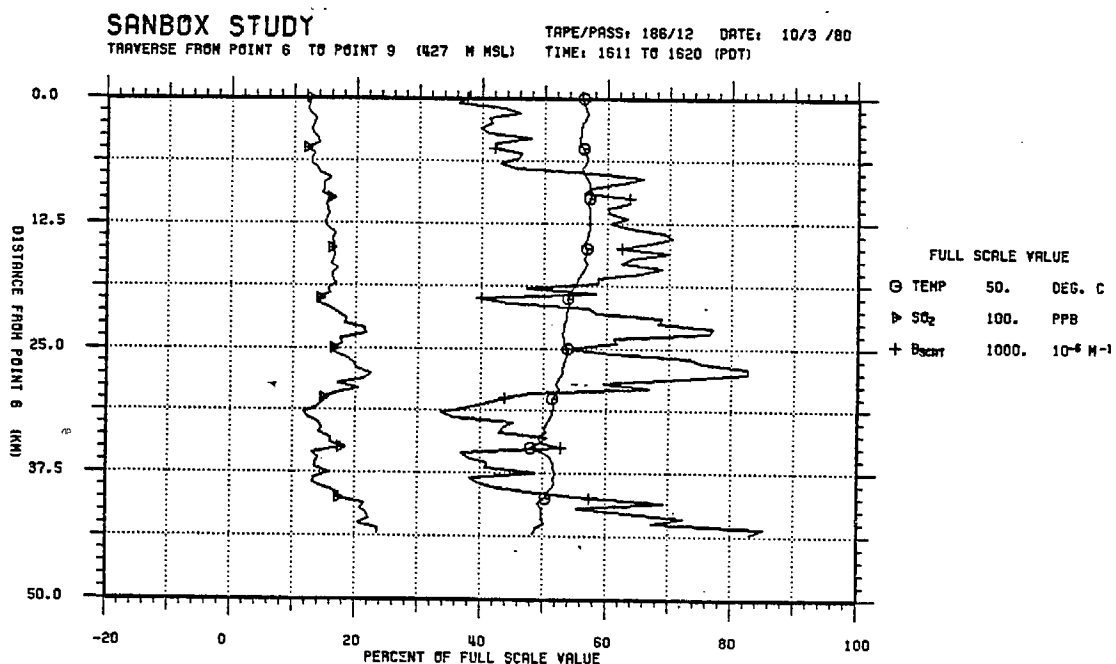
Fig. 4.7.10

821201.0
 17:39:48

increased sharply. Peak ozone value measured was 36 pphm at flight level. Peak surface concentration at Thousand Oaks on October 3 was only 17 pphm. The peak aloft near Thousand Oaks was accompanied by a peak in SO_2 but only a minor peak in NO_x . Near the end of the traverse ozone concentrations had decreased to 20-25 pphm.

The aircraft then reversed direction and flew from Ventura to Moorpark at 427 m-msl (274 m lower than the west bound traverse). Figure 4.7.11 shows the concentration observed along this path from 1611 to 1620 PDT. Ozone concentrations at flight level started at 25 pphm near the coast, increasing to over 30 pphm for most of the traverse but decreasing to 20 pphm at the end. Peak concentration at Moorpark was 19 pphm for the day.

The final spiral on October 3 was made at Santa Susana Airport (near Simi) at 1628 PDT (Figure 4.7.12). A low-level inversion was present with a base of about 450 m-msl. Again the highest ozone concentration (20 pphm) occurred in the low-level, marine layer. A slightly stable layer aloft began about 1200 m-msl and represented the top of an elevated ozone layer with peak concentration of 13 pphm. Wind flow throughout the layer to 1200 m-msl was from the west to southwest. NO_x , b_{scat} and SO_2 concentrations peaked in similar layers.

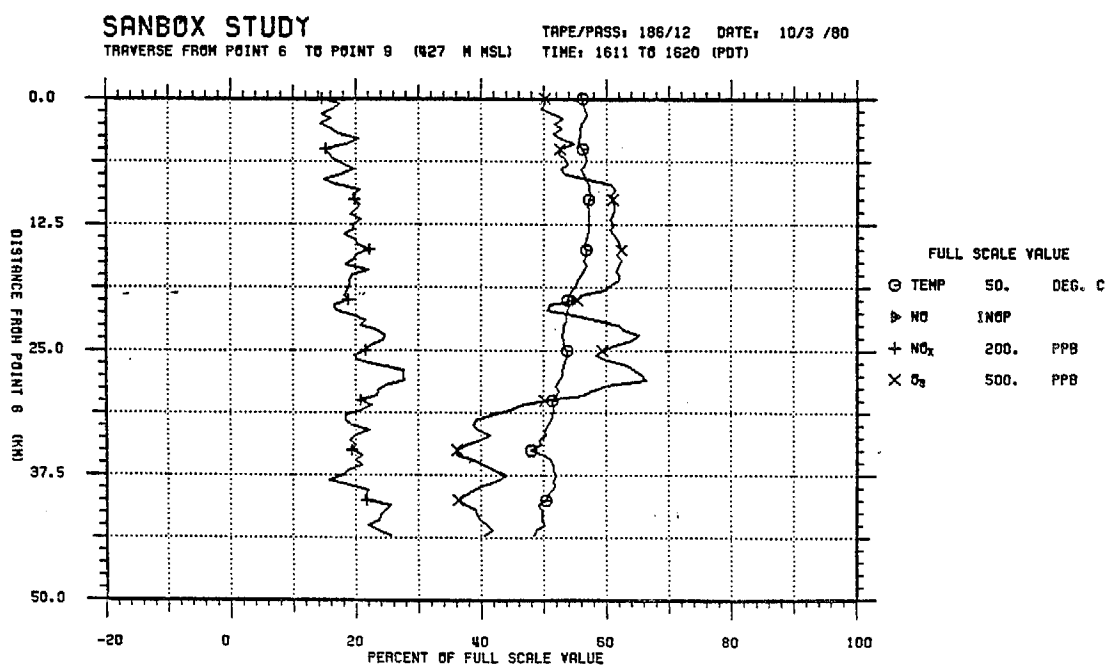


821201.0
17:39:48

AIRCRAFT TRAVERSE - VENTURA TO MOORPARK

(1611 PDT)

October 3, 1980



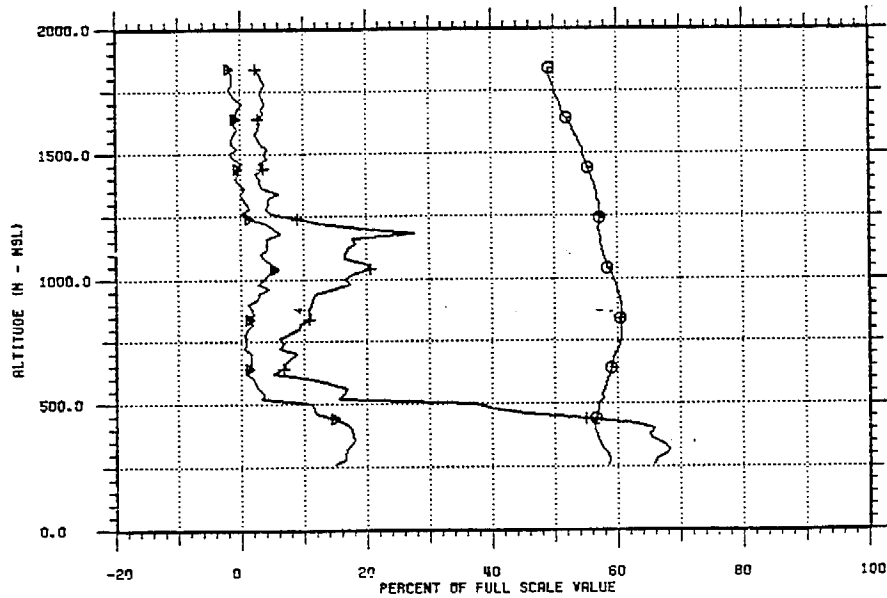
821201.0
17:39:48

Fig. 4.7.11

SANBOX STUDY

SPIRAL AT POINT 10

TAPE/PASS: 186/14 DATE: 10/3 /80
TIME: 1628 TO 1638 (PDT)



821201.0
17:39:48

AIRCRAFT SOUNDING AT SANTA SUSANA

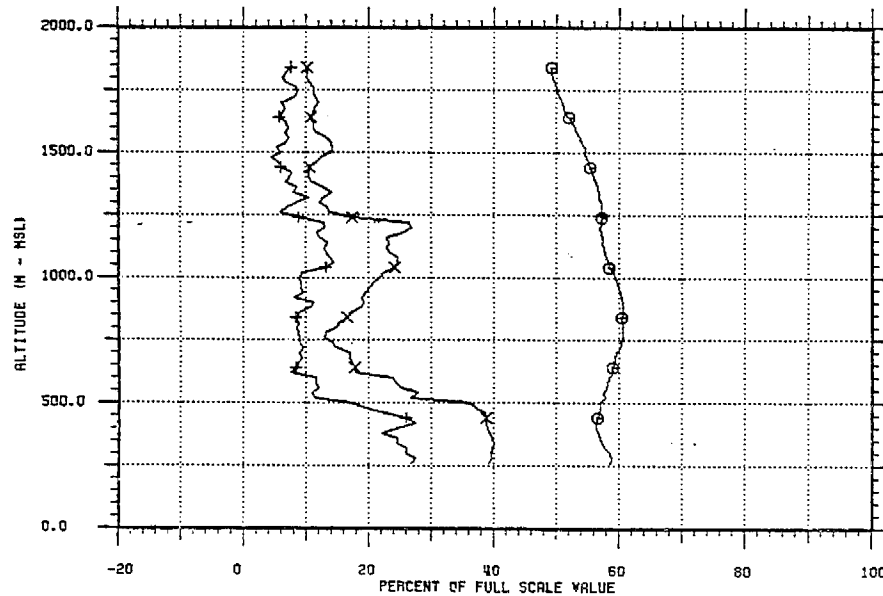
(1628 PDT)

October 3, 1980

SANBOX STUDY

SPIRAL AT POINT 10

TAPE/PASS: 186/14 DATE: 10/3 /80
TIME: 1628 TO 1638 (PDT)



821201.0
17:39:48

Fig. 4.7.12

4.7.6 Tracer Results - Test 6

Release Location: 4 mi SW of Port Hueneme
Date: October 3, 1980
Time: 0045-0545 PDT
Release Rate: 8.3 g of SF₆ per sec

Surface winds at Platform Grace (to the northwest of the release site) during the release period are given in Table 4.7.5.

Table 4.7.5

Surface Winds - Platform Grace October 3, 1980

Time	Wind Direction	Wind Speed
00 PDT	165°	2.6 m/s
01	355	3.1
02	206	3.2
03	100	3.6
04	96	3.4
05	109	3.2
06	94	3.7

Wind velocities during the release were light. Wind directions were somewhat variable but were primarily from the east to southeast.

Figures 4.7.13 and 4.7.14 show streamline charts for the period 00 to 12 PST on October 3. Surface winds over the channel were southeasterly during the entire morning. Onshore flow commenced along the immediate coast by 12 PST but did not influence the winds at Platform Grace and Hondo. At 15 PST the wind at Platform Hondo shifted to the southwest and remained from that direction until shortly before midnight.

The streamline patterns shown in the previous figures resulted in a tracer trajectory as indicated in Figure 4.7.15. The principal trajectory was directed to the northwest, reaching the vicinity of El Capitan Beach between 11 and 15 PDT. A small amount of SF₆ moved in to the Santa Ynez Valley, arriving about 14 PDT. An average travel speed of 2-3 m/s is indicated for the tracer material to move from the release point to El Capitan Beach. Observed times of peak concentrations at various locations are shown on the figure.

After 15 PDT the general wind shift toward a southwesterly direction carried the tracer material eastward along the coast, appearing in succession at Santa Barbara, Carpinteria and, finally, at Oxnard during the following morning. The tracer material arrived in the Ventura area after the seabreeze had ended. Consequently, the inland valleys were not appreciably affected.

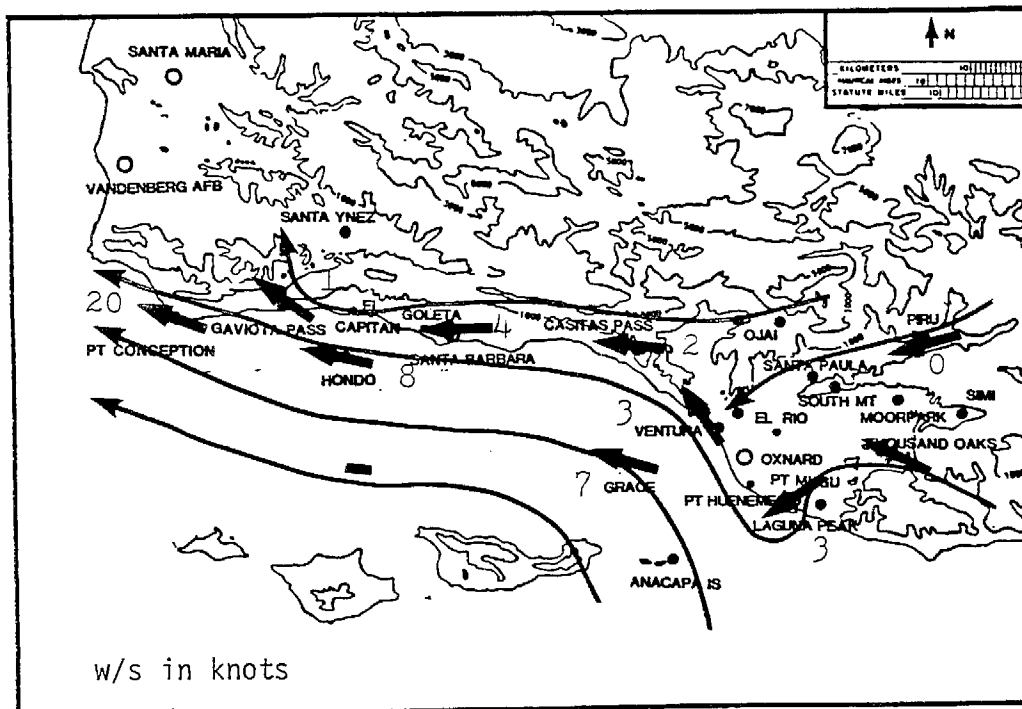
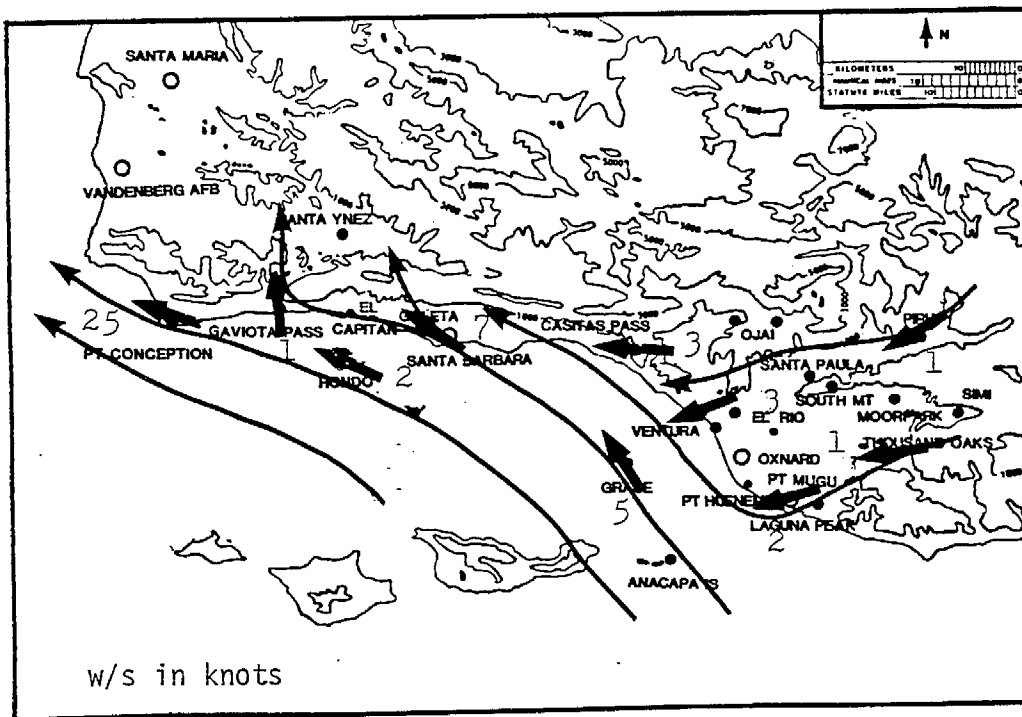


Fig. 4.7.13 STREAMLINE CHARTS - October 3, 1980

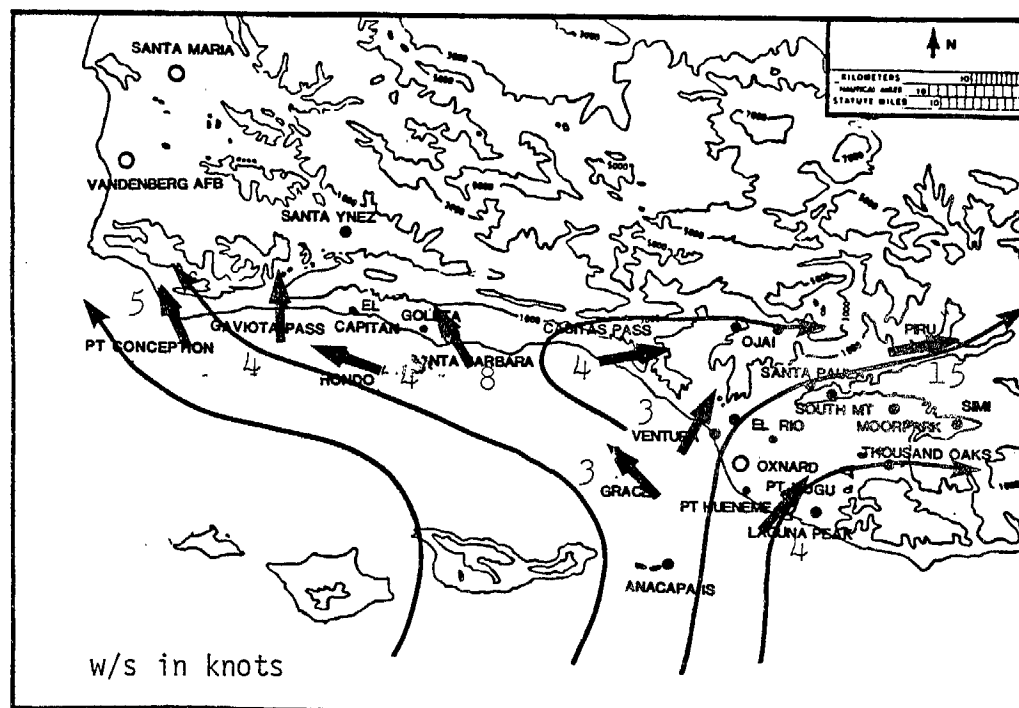
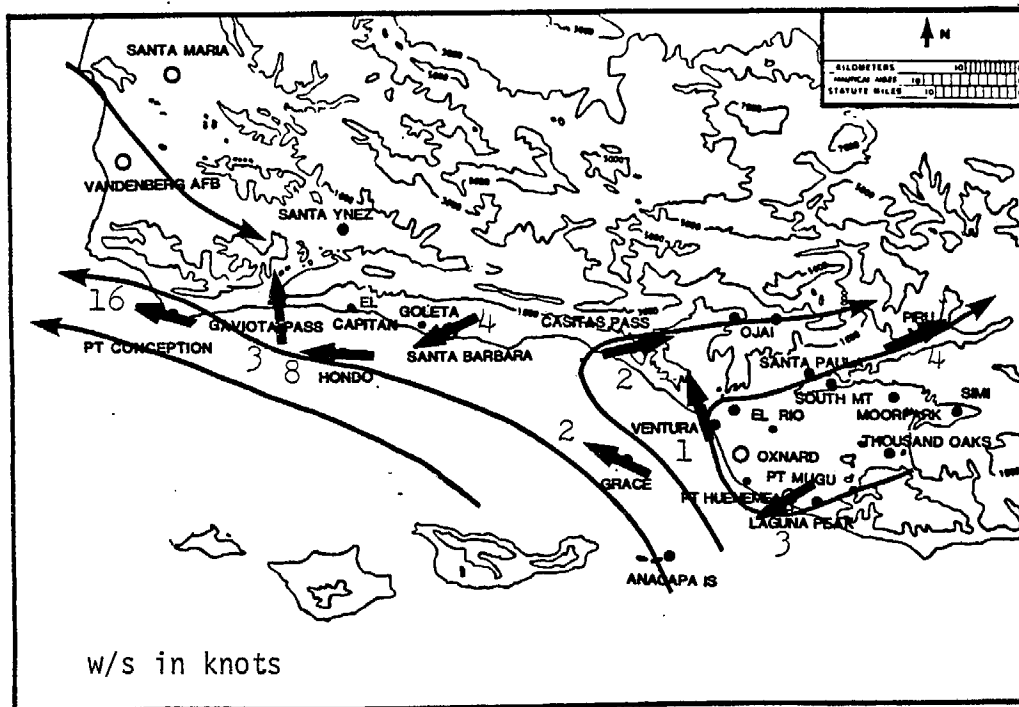


Fig. 4.7.14 STREAMLINE CHARTS - October 3, 1980

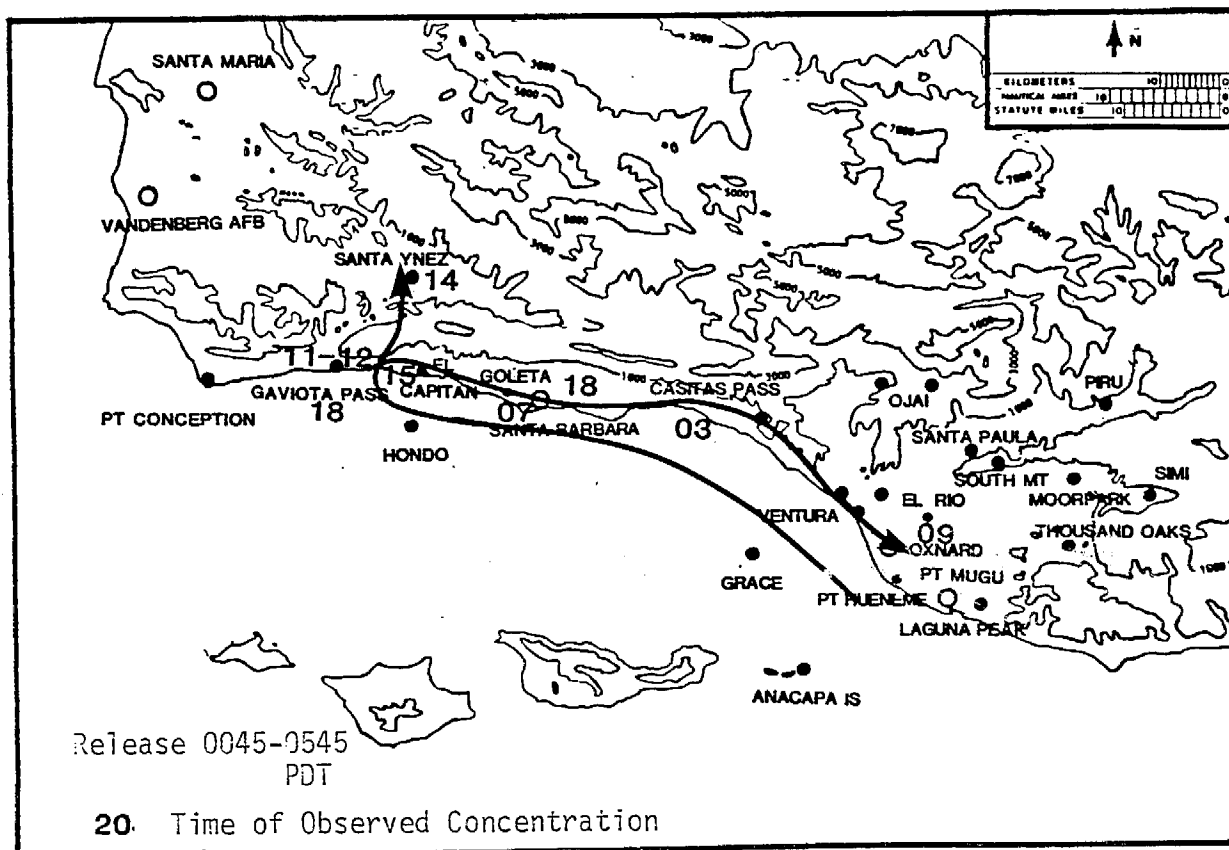


Fig. 4.7.15 _ ESTIMATED TRACER TRAJECTORIES - October 3, 1980

Xu/Q values have been computed for those SF₆ concentration data when the trajectory of the tracer material was relatively well understood. These values are given in Table 4.7.6 and plotted in Figure 4.7.16. Distances were measured along the trajectory as indicated in Figure 4.7.15.

There were no hourly tracer samples in the vicinity of Santa Barbara/El Capitan Beach where maximum impact from the tracer release appeared to occur. Highest Xu/Q values were observed by automobile grab samples which indicated an E-F category in Figure 4.7.16.

Table 4.7.6

Calculated Xu/Q Values
Test 6 - October 3, 1980

Wind Speed	Location	Time	Type of Sample	Distance	Xu/Q ($\times 10^{-6}$)
3.1 m/s	Carpinteria	03 PDT	H	160 km	.03 m ⁻²
	Oxnard	09	H	190	.06
	Santa Barbara	07	H	140	.06
	Santa Barbara	03	H	140	.03
	El Capitan	11	A	110	.74
	El Capitan	12	A	110	.99
	Santa Ynez	14	A/C	110	.12

H - Hourly sample
A - Automobile sample
A/C - Aircraft sample

The aircraft sample taken at Santa Ynez showed a somewhat lower Xu/Q value as did the four hourly samples observed after the tracer material had reversed direction and moved back toward the east. The trajectory represented by the wind shift from southeasterly to southwesterly would be expected to result in a horizontal dilution of the tracer cloud and a consequent reduction in dosages along the eastward path.

Total SF₆ dosage values were computed for the hourly sampling stations for the 24-hour period of maximum impact. These dosages are given in Table 4.7.7.

7-16

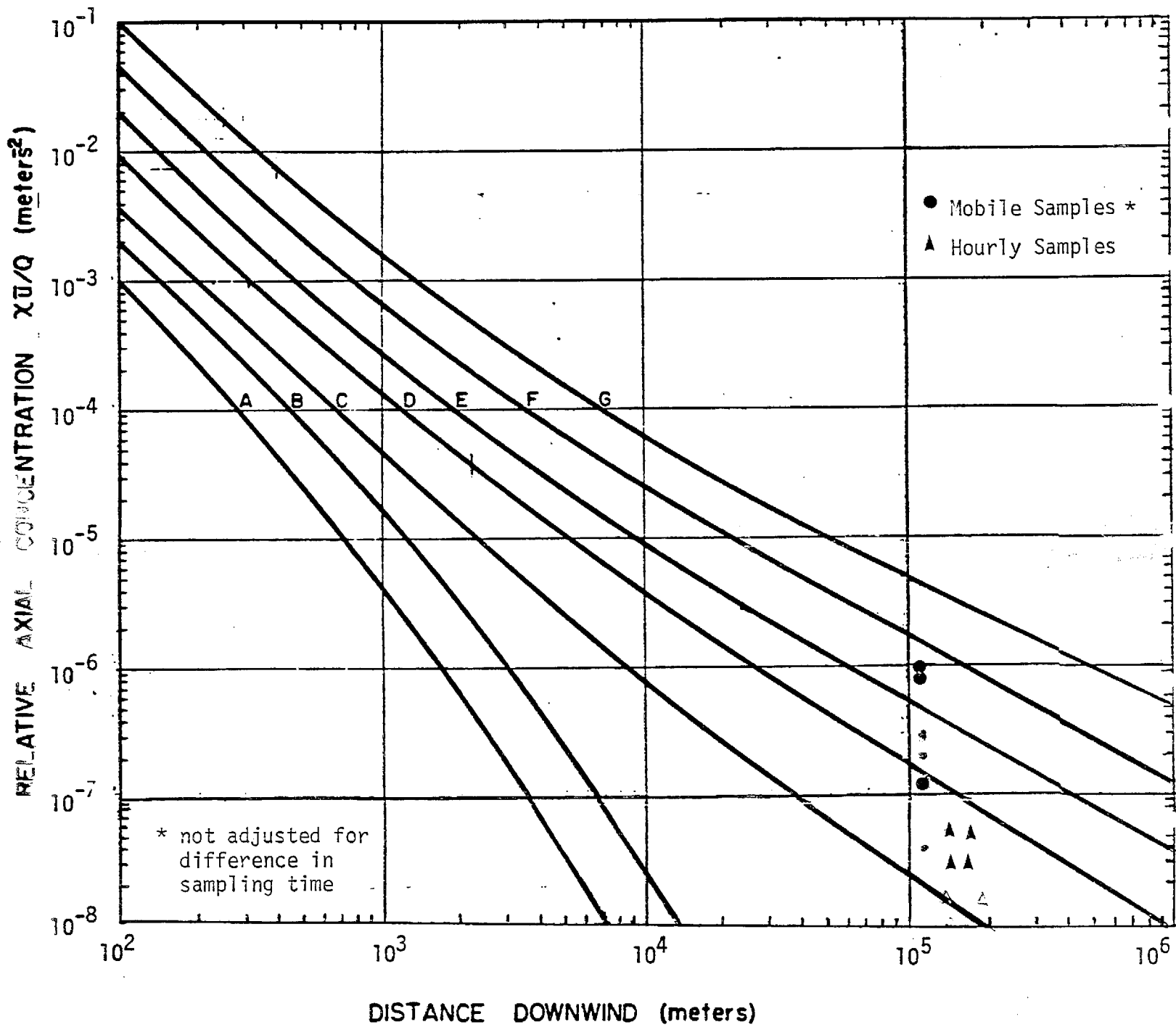


Fig. 4.7.16 $\bar{X}U/Q$ VALUES - Test 6

October 3, 1980

Table 4.7.7

Total SF₆ Dosages
Test 6 - October 3, 1980

Location	Total Dosage	Number of Hours \geq 10 ppt
Santa Barbara	133 ppt	9
Carpinteria	95	7
Ojai	89	7
Ventura	73	5
Santa Paula	101	8
Piru	21	2
Oxnard	66	4
Camarillo	38	3
Thousand Oaks	74	4
Simi	46	4

The principal short-term tracer impact was observed in the El Capitan Beach area as a result of the direct trajectory from the release toward the northwest. No hourly samples were taken in this area so that Santa Barbara appeared to have the highest, observed total dosage. In contrast with the results of Test 5, all of the observed total dosages were relatively small.

The distribution of tracer material observed by auto traverses on October 4 is given in Figure 4.7.17. The figure shows all of the traverse routes followed during the day (0740-1501 PDT). Areas where concentrations greater than 10 ppt were found are shown as shaded sections. Peak concentration observed was 29 ppt near Moorpark between 1125 and 1215 PDT. Apparent carry-over concentrations were widespread as indicated in Figure 4.7.17, but were not very large in value, partly because the original concentrations on October 3 were relatively small.

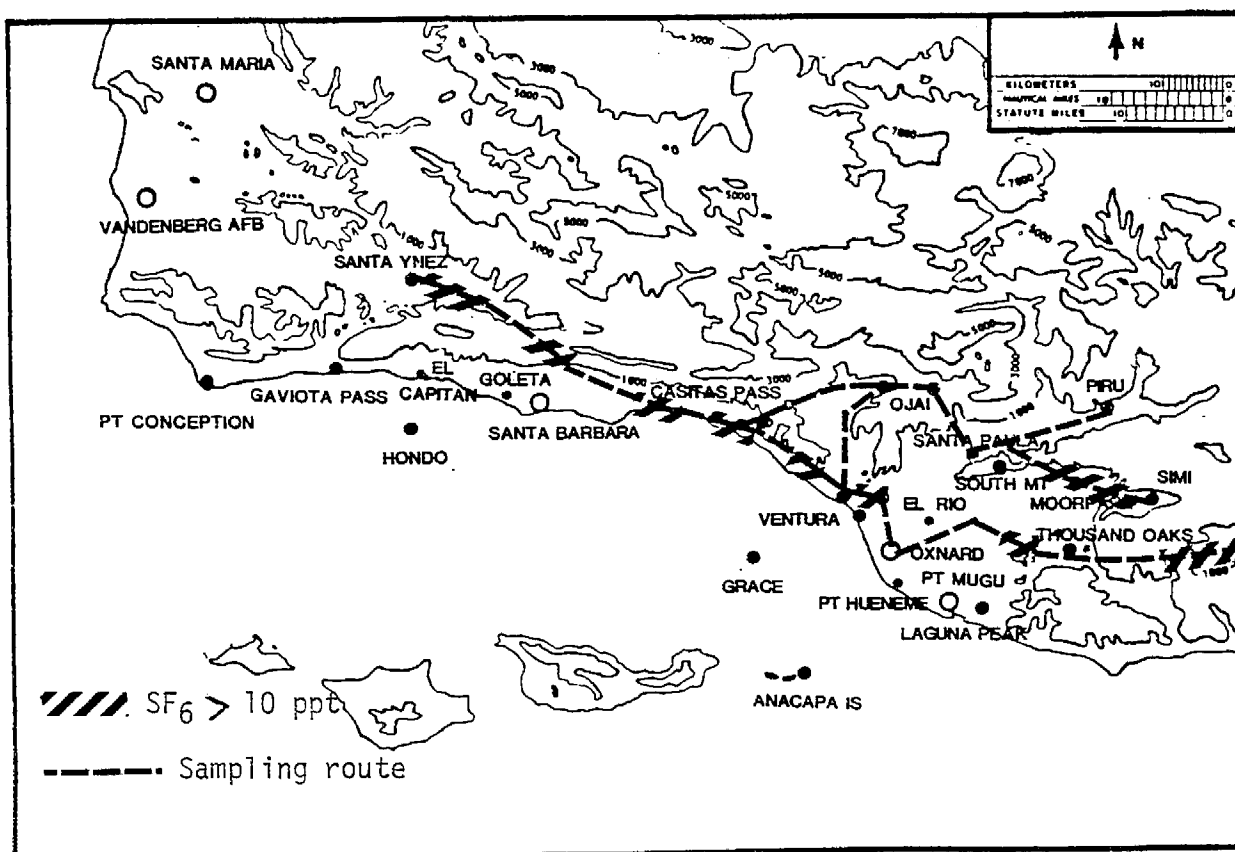


Fig. 4.7.17 LOCATIONS OF SF₆ CONCENTRATIONS - October 4, 1980

(> 10 ppt)

5.0 ANALYSIS TOPICS

5.1 Meteorological Conditions Associated With High Ozone

Ozone concentrations in the Ventura/Santa Barbara area are strongly influenced by meteorological conditions within the basin. It has become customary in California to express a large portion of the meteorological relationship in terms of a single parameter, the 850 mb (4 A.M.) temperature (about 5,000 ft msl). The principal physical effect expressed by warm temperatures aloft is a tendency for a temperature inversion and limited upward transport of pollutants. This is particularly important when over the water surface temperatures remain constant from day to day while the upper level temperatures increase.

A scatter diagram of the 850 mb (4 A.M.) temperature at Vandenberg AFB vs. the maximum daily ozone concentration at Piru is shown in Fig. 5.1.1. Also shown is the 850 mb temperature plotted against the daily maximum ozone concentration observed anywhere in the Ventura/Santa Barbara network. As can be seen, the two plots are very similar but a slight improvement in correlation is obtained by use of the highest concentration in the area.

Subjective lines of best-fit are drawn in each figure. The standard deviation about each best-fit line is of the order of 2 pphm.

In spite of the apparent relationship expressed by use of the 850 mb temperature, there are variations in concentration which need further explanation. As an example, peak ozone concentrations on September 26 and 28 were observed as follows:

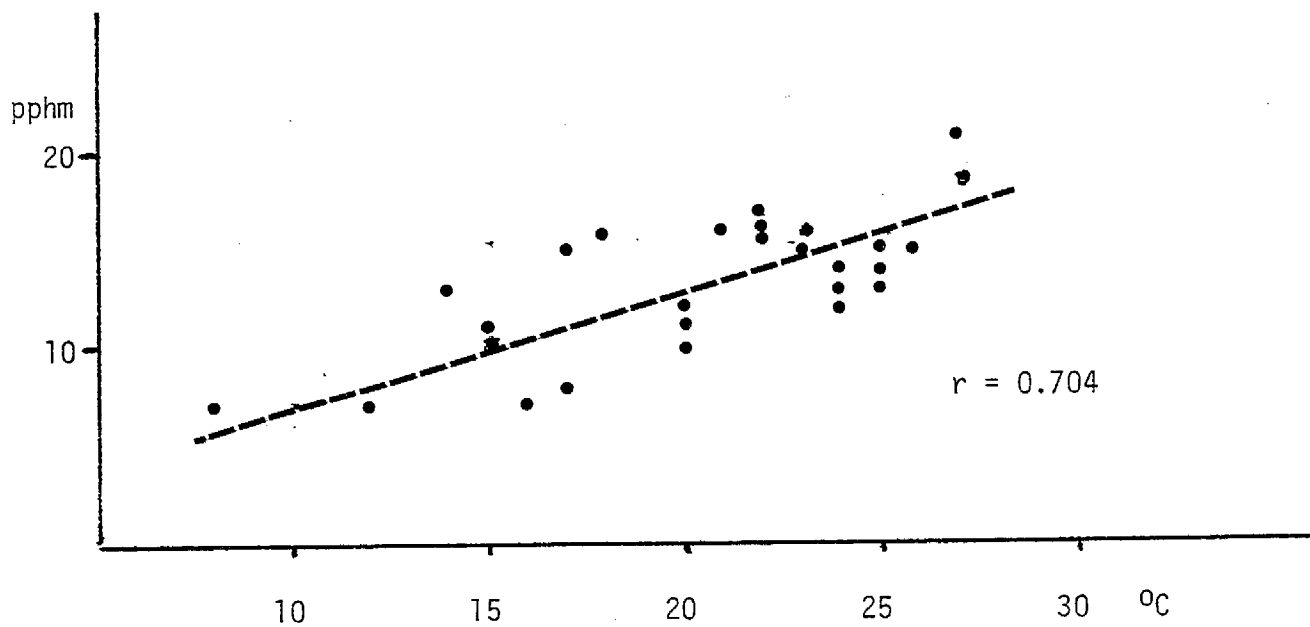
Table 5.1.1

Peak Ozone Concentrations

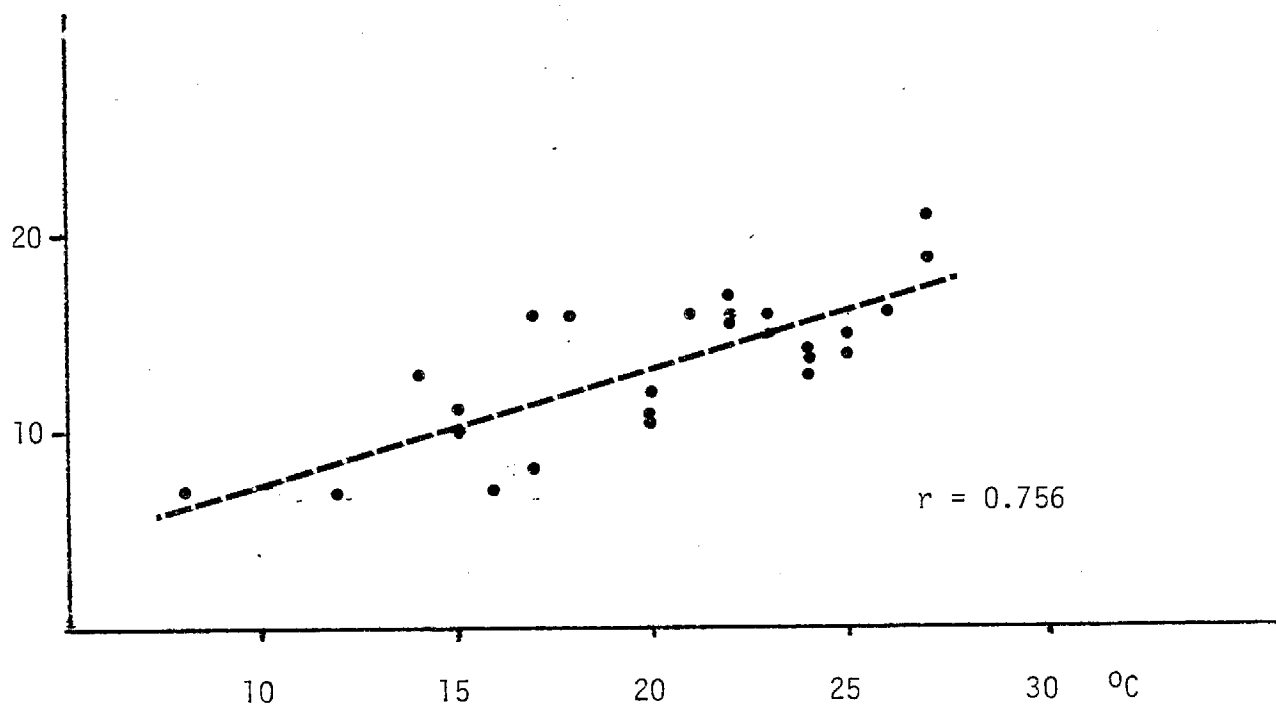
September 26	(850 mb Temp. 21°C)	September 28	(850 mb Temp. 20°C)
Ojai	14 pphm	Ojai	10 pphm
Piru	16 pphm	Piru	12 pphm

The 850 mb temperature difference should account for only one pphm difference in ozone and it is necessary to consider other sources of the remaining differences. A similar variation occurred on October 1 when a peak hourly ozone reading of 9 pphm was observed at Ojai compared to a peak of 15 pphm at Piru. The data in October provide an insight into the regional difference between Ojai and Piru.

A number of aircraft soundings were made on October 1 which contain important data on the vertical pollutant structure from Platform Grace to Piru. The sounding information is summarized in Table 5.1.2. The soundings themselves were discussed in Section 4 and are repeated here.



a. Maximum Ozone Concentration at Piru



b. Maximum Ozone Concentration in Ventura Area

Fig. 5.1.1 850 mb TEMPERATURE vs MAXIMUM OZONE CONCENTRATION
(September 12 to October 11, 1980)

Table 5.1.2

Summary of Sounding Data - October 1, 1980

<u>Figure No.</u>	<u>Location</u>	<u>Time</u>	<u>Top of Marine Layer</u>	<u>Peak O₃ in Layer</u>
4.6.7	Platform Grace	1449 PDT	300 m-msl	14 pphm
4.6.3	Ventura Marina	1341 PDT	300 m-msl	18 pphm
4.6.11	Santa Paula	1600 PDT	400 m-msl	14 pphm
4.6.10	Piru	1539 PDT	600 m-msl	14 pphm

Soundings for Platform Grace and Ventura Marina are shown in Fig. 5.1.2; those for Santa Paula and Piru are given in Fig. 5.1.3.

The soundings in Fig. 5.1.2 show a strong temperature inversion resulting from the cool ocean temperatures and unusually warm air aloft. In the lowest 300 m there was a layer of ozone present in both soundings with peak concentration of 14 and 18 pphm but with somewhat lower concentrations at the surface. In Fig. 5.1.3 the same layer is shown but with slightly greater depth. The high concentrations also extend to the surface for the inland stations.

This series of soundings illustrates the effects of a shallow layer of cool air, generated over the water and then being advected inland with the consequent development of an undercutting layer as far inland as Piru. The stability of the top of this layer permits only slight upward dilution of the pollutants and the peak ozone concentrations remained about 14 pphm.

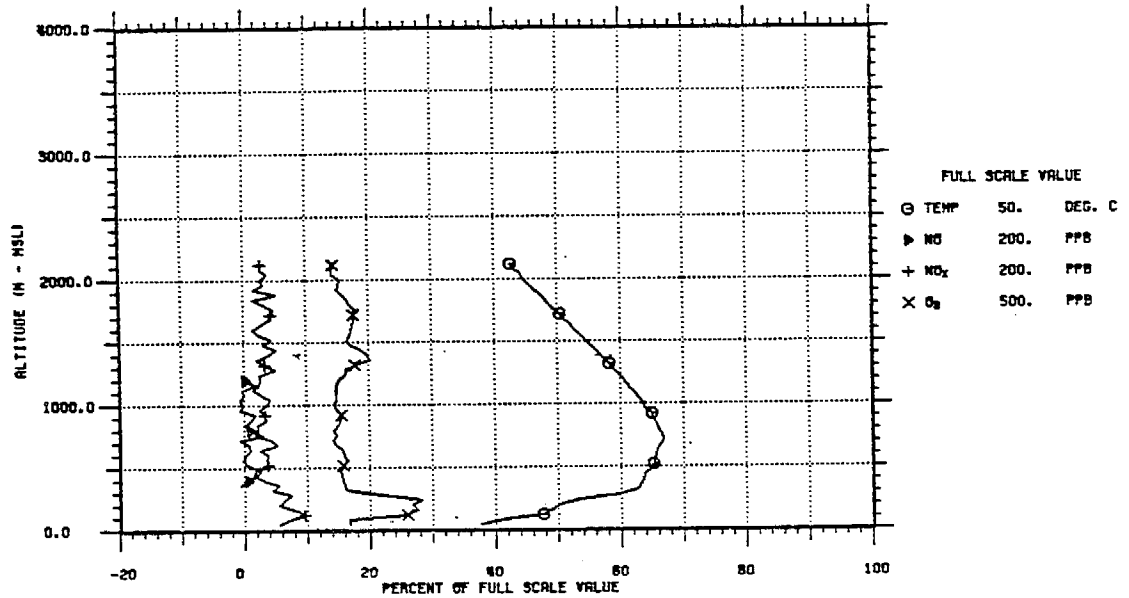
The arrival of this layer at Piru and Simi is shown in Fig. 5.1.4 by the time histories of ozone concentrations. A sharp rise in concentration occurs at 14 PST at Piru and 13 PST at Simi. Peak temperature at Piru was reached at 11 PST, prior to the arrival of the marine air. No such change in ozone occurred at Ojai and it is apparent that the pollutant layer did not reach that location.

It is suggested that a portion of the variability in peak ozone concentrations can be attributed to the behavior of this marine layer.

Two other sources of variability should be mentioned. The first of these is variability in emission source strength about which there is little information on day-to-day variations. The second source of variability is the level of background ozone entering the area from upwind. It was noted in Section 4 that this background, as measured by the aircraft soundings, varied between 2-3 pphm and 7-8 pphm with a most frequent value around 5 pphm.

SANBOX STUDY
SPIRAL AT POINT 5

TAPE/PASS: 185/7 DATE: 10/1 /80
TIME: 1448 TO 1505 (PDT)

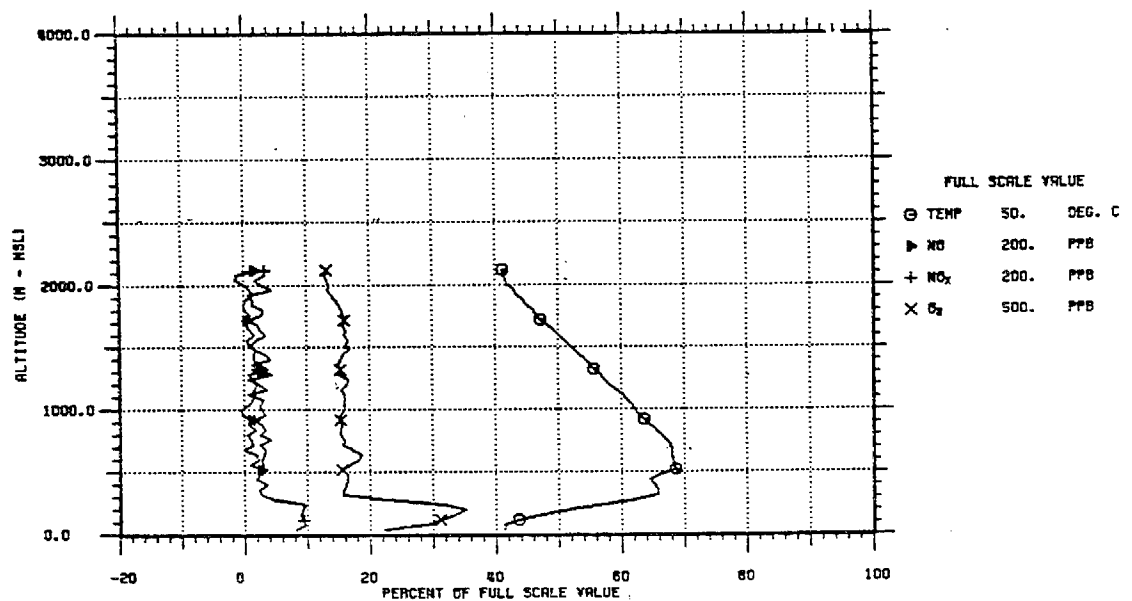


a. Platform Grace - (1449 PDT)

621201.0
17:01:58

SANBOX STUDY
SPIRAL AT POINT 1

TAPE/PASS: 185/2 DATE: 10/1 /80
TIME: 1341 TO 1355 (PDT)

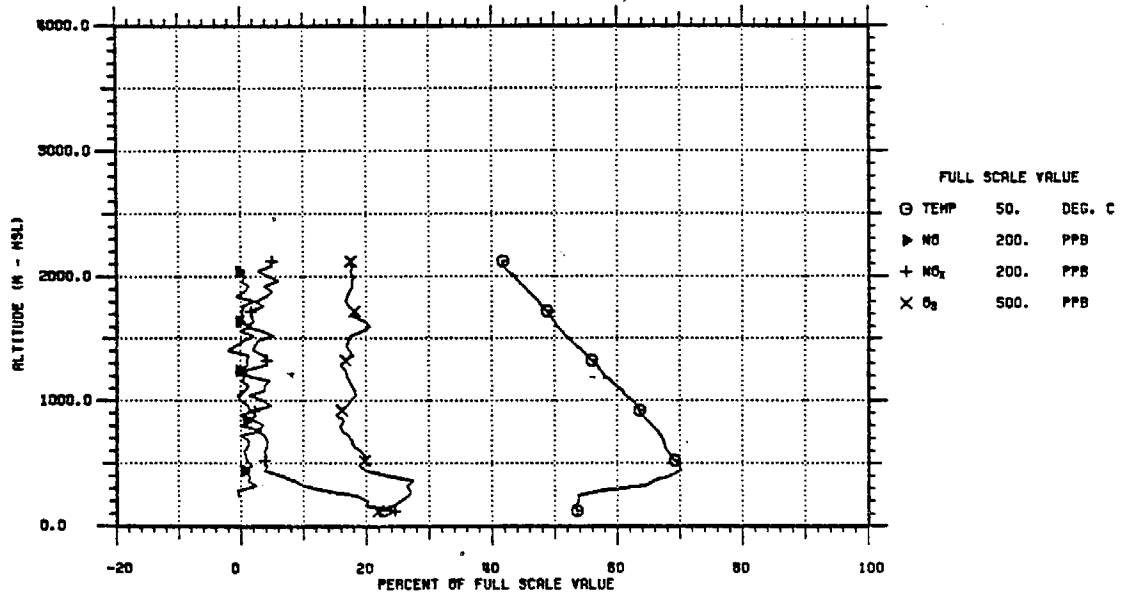


b. Ventura Marina - (1341 PDT)

621201.0
17:01:58

SANBOX STUDY
SPIRAL AT POINT 7

TAPE/PASS: 185/12 DATE: 10/1 /80
TIME: 1550 TO 1612 (PDT)

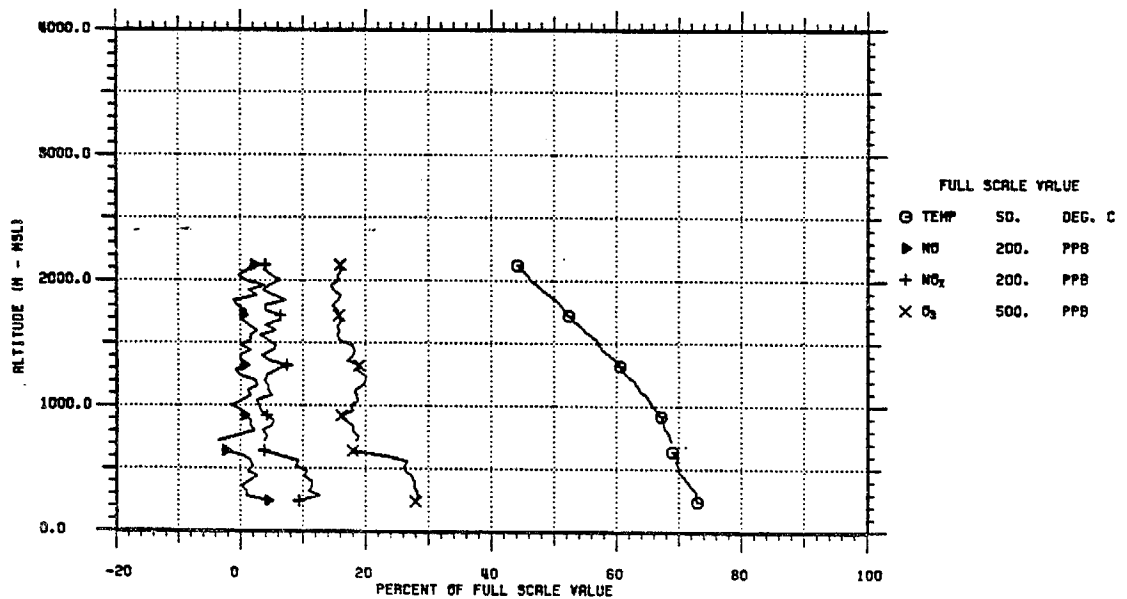


a. Santa Paula (1600 PDT)

821201.0
17:01:58

SANBOX STUDY
SPIRAL AT POINT 6

TAPE/PASS: 185/11 DATE: 10/1 /80
TIME: 1539 TO 1554 (PDT)



b. Piru (1539 PDT)

821201.0
17:01:58

Fig. 5.1.3 AIRCRAFT SOUNDINGS - October 1, 1980

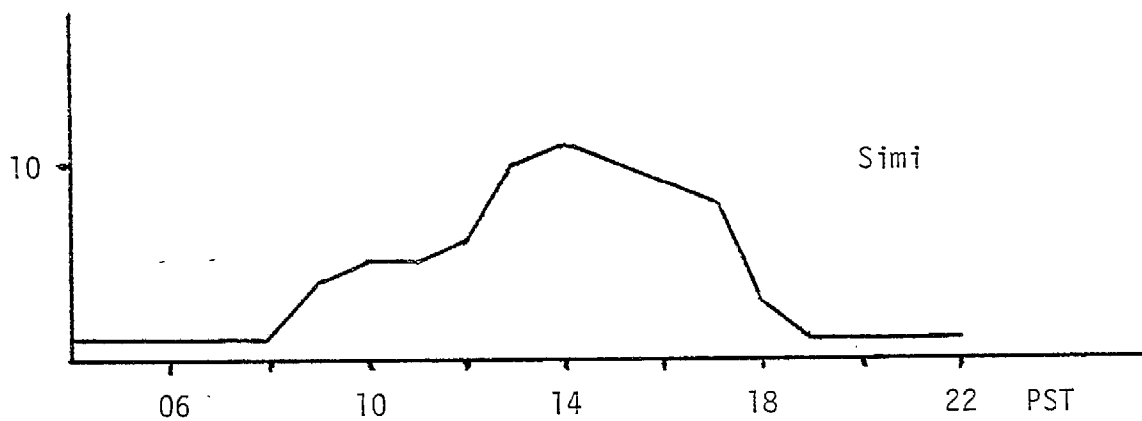
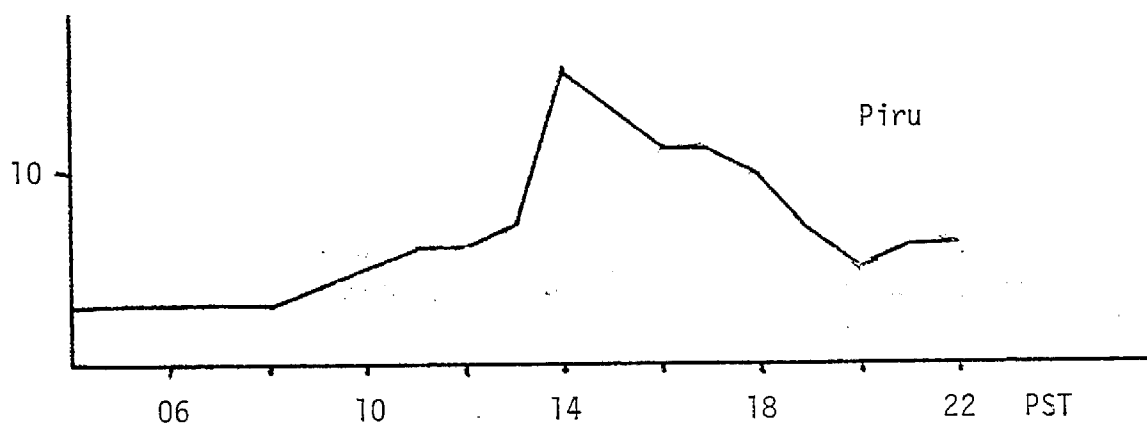
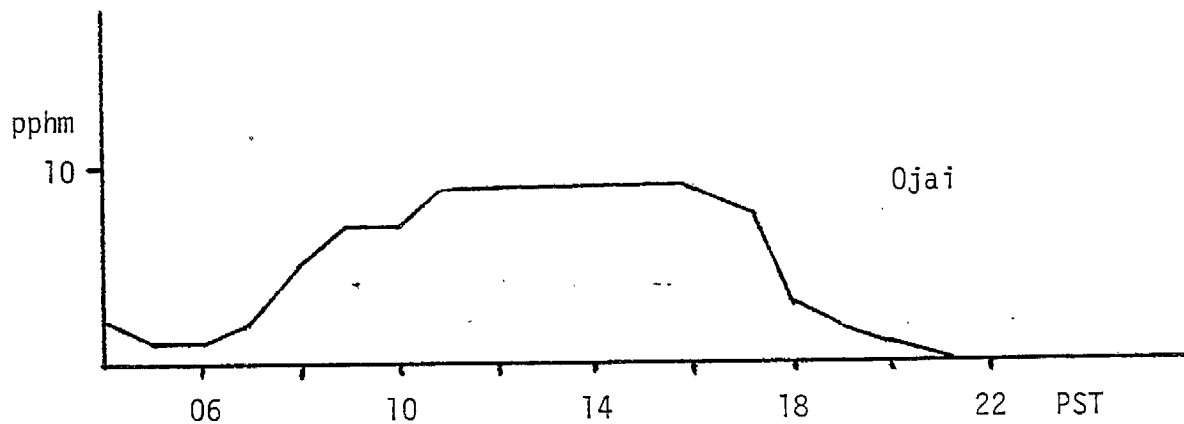


Fig. 5.1.4 HOURLY OZONE CONCENTRATIONS - October 1, 1980

The data plotted in Figs. 5.1.2 and 5.1.3 also illustrate the effects of fumigation of an elevated layer after passing the coast line. The soundings show reduced ozone concentrations near the surface at Platform Grace and at Ventura. Concentrations from the elevated layer have mixed to the surface at Santa Paula and Piru. Based on the sounding at Platform Grace, a surface temperature of 86°F would have been necessary to raise the surface mixing layer to the top of the ozone layer (300 m-msl). The maximum surface temperature needed at Santa Paula on October 1 was 101°F so that mixing to the surface should have occurred between Ventura and Santa Paula.

5.2 Summary of Tracer Trajectories

Estimated trajectories for the tracer material released during each test have been presented in Section 4. An overview of each test is given below:

Test 1 (September 17) - The winds in the channel were relatively strong. Tracer material moved from Pt. Conception to the Ventura coast in about 4 hours, arriving between 15 and 18 PDT. As a consequence of the arrival time, the SF₆ was carried inland by the existing seabreeze flow which has a normal duration of 09-19 PDT during this period of the year. The material arriving around 18 PDT was incorporated into the dying end of the seabreeze and was apparently not carried very far inland. There is evidence that some of this material may have remained in the coastal plain throughout the night.

By the beginning of the release period from Pt. Conception (11 PDT) the flow in the channel had shifted to a westerly direction except for remnants of a "Gaviota" eddy with southerly winds at Gaviota and Santa Barbara. This flow resulted in direct tracer impact between Santa Barbara and El Capitan Beach. By 15 PDT this eddy structure had almost disappeared and the flow became more westerly throughout the channel.

Test 2 (September 22) - Winds in the channel area were substantially lighter than on September 17 and were of the order of 1 m/s at the beginning of the release near Pt. Conception. This permitted considerable dilution in the tracer cloud prior to the wind shift to westerly which occurred at 12 PDT at Pt. Conception. Thereafter, winds in the channel remained lighter than on September 17 and the peak of the tracer did not appear at the Ventura coast until 23 PDT, about 10-12 hours after release. The late arrival did not permit incorporation into the seabreeze flow along the Ventura coast and tracer material did not reach the inland valleys in substantial quantities. Obviously, material released from a point closer to the coast might have reached the coast in time to be included in the seabreeze flow.

The impact of the "Gaviota" eddy was similar to that observed on September 17. SF₆ material appeared in the afternoon from El Capitan Beach to Santa Barbara.

Test 3 (September 26) - Tracer material was released from Platform Hondo from 02-07 PDT under light, northeasterly wind conditions. Some of the material moved to the southwest and was then swept eastward to the

Ventura coast by the westerly wind prevailing in the southern part of the channel. Travel time to the Ventura coast was about 5-6 hours, arriving there about 12 PDT. This timing fit well with the development of the seabreeze and the material was carried well inland, peaking at Piru at 16 PDT, coincident with the O₃ peak.

A second branch of the tracer material was carried by the "Gaviota" eddy into El Capitan Beach and Gaviota. The onshore flow at Gaviota started at 10 PDT.

Test 4 (September 28) - The tracer material was released from the R/V Acania (4 miles off Ventura) directly into the seabreeze flow. The release started at 1240 PDT and lasted to the end of the seabreeze, near 19 PDT. The tracer material was obviously carried inland, with a primary total impact at Santa Paula and Oxnard. The peak SF₆ arrived slightly after the peak ozone had been reached at Ojai. The air parcels containing the ozone at Ojai must, therefore, have left the coastal region between 09 and 12 PDT.

Rather sizeable amounts of tracer were observed on the following day at Santa Barbara and Carpinteria. According to the wind flow patterns this material was carried westward from the inland valleys, reaching Santa Barbara and Carpinteria on the morning of September 27.

Test 5 (October 1) - The release from near Platform Grace was carried out with southeasterly winds throughout most of the channel. These resulted from a stronger than normal offshore pressure gradient with winds even at Pt. Conception being easterly at 10-18 knots during the night prior to the release. The shift to a westerly wind in the channel began at Pt. Conception by 11 PDT but did not occur at Platform Grace until 16 PDT. Under these conditions the early part of the tracer plume started in a direction toward Santa Barbara, arriving in 8-9 hours. Later portions of the tracer plume were more and more affected by the shift to a westerly wind and impacted the coast in a wide area from Ventura to Santa Barbara.

The principal impacts were along the coast. The material was not available along the Ventura coast in time for effective transport by the seabreeze flow and, as a consequence, total dosage at Piru was very small.

Test 6 (October 3) - The release from off Port Hueneme was again made under conditions of southeasterly winds throughout the channel. Winds of 25 knots from the southeast were observed at Pt. Conception during the night prior to the release. The tracer material was carried northwestward to near El Capitan Beach in a period of about 9 hours.

The customary wind shift to westerly occurred at 15 PDT at Pt. Conception and 16 PDT at Platform Grace. The wind shift caused the late portion of the tracer release to move back toward the east along the coast through Carpinteria and finally to Ventura by the following morning. The material arrived along the southern coast too late for a seabreeze influence and very little SF₆ was observed in the inland valleys.

The foregoing overview of the tracer trajectories describes a complex system of flow patterns in which the impact point and magnitude is not only dependent on the location of the release but on the time of release as well as the overall weather pattern. There is a relatively simple flow pattern (e.g., Test 1) in which a steady, westerly wind exists throughout the channel for a sufficient time to transport material to the coast. The other example of a steady, organized flow occurred in Test 4 when the tracer material was introduced directly into the seabreeze flow near the coast line. These patterns could readily be subjected to modeling exercises.

In the balance of the tests, because of timing and/or location, the tracer material was subjected to marked shifts in wind direction and uncertain trajectories which would make modeling very difficult. The effect of a wind shift on a long plume is an apparent, very rapid dilution as each part of the plume becomes, in effect, a new source.

The tracer trajectories point out clearly the dynamic nature of the flow patterns in the channel, their effect on plume transport and the necessity to consider seabreeze timing as an effective way of transporting material inland.

5.3 Dispersion Summary

Xu/Q values for each of the tracer tests are shown in tabular and graphical form in Section 4. The following provides a summary and interpretation of the values related to Pasquill stability categories.

Tracer trajectories shown in Section 4 have been divided into two categories; those in which an organized flow existed throughout the trajectory which provided direct impact on the sampling station and those in which the trajectory was subject to light or meandering winds or was influenced by a pronounced wind shift.

Test 1 - September 17, 1980

The flow in the channel was relatively strong and well organized. Most of the samplers received a direct impact of the tracer material.

<u>Sample Location</u>	<u>Time</u>	<u>Distance</u>	<u>Stability Category</u>
El Capitan Beach	17 PDT	60 km	G
Ellwood	17 PDT	60 km	G
Santa Barbara	16 PDT	80 km	F-G
Carpenteria	15 PDT	100 km	G
Santa Barbara	15 PDT	75 km	G
Goleta	16 PDT	70 km	G
Platform Hondo	14 PDT	38 km	G
Santa Barbara	18 PDT	75 km	F-G
NW of Ventura	18 PDT	100 km	F-G
Santa Barbara	19 PDT	75 km	F
Santa Barbara	16 PDT	75 km	G

The balance of the samples shown in Section 4 were taken at inland locations:

<u>Sample Location</u>	<u>Time</u>	<u>Distance</u>	<u>Stability Category</u>
Camarillo	19 PDT	150 km	D
Ojai	18 PDT	130 km	D
Oxnard	16 PDT	135 km	D
Piru	22 PDT	165 km	D
Santa Paula	18 PDT	145 km	D

For the inland stations it is much more difficult to be assured that the maximum tracer concentration has been sampled. In contrast, along the coast, detailed traverses can be made which can locate the maximum rather readily. In spite of this restriction, it appears that considerable dilution takes place as the tracer cloud moves inland.

Test 2

Light winds prevailed during the early part of the tracer transport. Most of the material was subjected to a marked westerly wind shift shortly after release. There were no sampler stations considered to be under direct impact of an organized flow. All samples obtained corresponded to D or E categories.

Test 3

A similar but even more pronounced condition existed during this test. The tracer release was from 02 to 07 PDT at Platform Hondo under light north-easterly winds. These subsequently shifted to west and southwest. All trajectories were considered to be subject to meandering or wind shift conditions. All significant tracer samples corresponded to categories C or D.

Test 4

The tracer material was released about 4 miles offshore in an organized seabreeze flow. All sampling stations could be considered to be influenced by moderate, organized flow. The primary sampling problem for such short downwind distances is whether the true maximum concentration has been sampled.

<u>Sample Location</u>	<u>Time</u>	<u>Distance</u>	<u>Stability Category</u>
Ventura	14 PDT	6 km	E
Ventura	15 PDT	6 km	E
Ventura	16 PDT	6 km	E-F
Ventura	17 PDT	12 km	E

The remaining maximum concentrations were obtained at inland locations.

<u>Sample Location</u>	<u>Time</u>	<u>Distance</u>	<u>Stability Category</u>
Camarillo	23 PDT	42 km	D
Piru	20 PDT	53 km	D-E
Santa Paula	20 PDT	30 km	E-F
Thousand Oaks	20 PDT	43 km	C
W of Santa Paula	18 PDT	25 km	E
Santa Paula	17 PDT	25 km	E.

The sampling locations along the coast generally experienced E to E-F stability conditions while the inland stations apparently corresponded to somewhat more unstable categories.

Test 5

The release was made from near Platform Grace during the morning. The trajectory of the material was toward the north and northwest. It appeared to reach Santa Barbara and Carpinteria in a direct impact. From Carpinteria southward the tracer material was subjected to a marked wind shift toward a westerly direction.

<u>Sample Location</u>	<u>Time</u>	<u>Distance</u>	<u>Stability Category</u>
Santa Barbara	14 PDT	35 km	E
Carpinteria	15 PDT	30 km	G
SE of Santa Barbara	16 PDT	30 km	E-F
SE of Santa Barbara	17 PDT	20 km	E-f

These samples corresponded to stable categories ranging from E to G. The remaining samples, obtained to the south of Carpinteria ranged from a C to a D category.

Test 6

The tracer material was released 4 miles off Port Hueneme in a southeasterly flow. The trajectory carried the tracer to the northwest past Santa Barbara and El Capitan Beach. Between Gaviota and El Capitan Beach the trajectory reversed with the wind shift to west and eventually tracer was transported along the coast to Oxnard.

There were no adequate SF₆ measurements of the maximum, direct impact zone west of Santa Barbara. The remainder of the concentrations obtained after the wind shift corresponded to a C or D category.

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All releases were made a short distance offshore in an organized, seabreeze flow. Sampling was confined primarily to the immediate coastal area. All sampling stations could be considered to be subject to direct impact and all corresponded to slightly stable categories ranging from D-E to F-G. Data from September 28 (Test 4 above) fit an F category in contrast to the E or E-F shown above.

All releases were made a short distance offshore in an organized onshore flow. Sampling occurred to a distance of 16 km, in some cases. All concentrations corresponded to E, F, or G category with one exception (January 15) which appeared to be a D.

It has become recognized that effectiveness of dispersion over the water is reduced compared to over-land conditions. This is due primarily to differences in roughness but, in the channel area, also to relatively cool sea surface temperatures which result in low level stability. Zannetti et al. (1981) have suggested that the stability category be increased by one (e.g., D to E) if one wishes to model the dispersion with Pasquill stability categories.

The decreased over-water dispersion is borne out by all of the above data as long as direct impact with an organized flow pattern is considered. Evidence from the present study suggests, however, that light winds and wind shifts over the water increase the cloud dilution very significantly. The analyses of flow patterns in the area indicate that these light winds and wind shifts occur frequently, particularly under the summer, episode conditions when highest ozone concentrations occur.

5.4 SF₆ Cloud Widths

The sampling traverses conducted via automobile, airplane, and boat provide an opportunity to examine the horizontal structure of the tracer plume. In the following paragraphs, data for some of the plume transects will be presented which provide estimates of the horizontal cloud width, σ_y . A stability class can then be determined from the σ_y values and the downwind distance from the release point and compared to Pasquill categories.

An extensive array of traverses was carried out for each tracer test. The sample routes were designed primarily to cover the entire sampling grid to facilitate assessment of the tracer plume trajectories. The effort toward obtaining complete plume transects for the purpose of cross-sectional plume evaluation was a secondary goal. Thus, only a few traverses were suitable for the plume width analysis.

Obtaining a σ_y value from a plume transect involves fitting a Gaussian curve over the transect plot. The σ_y value represents one standard deviation from the plume centerline. A geometric correction factor was needed in cases where the traverse route was not perpendicular to the wind direction. The wind trajectory of the sampled plume parcel was then traced back to estimate the downwind distance of the parcel from the source. The Pasquill stability classification scheme was then utilized to estimate the stability class.

Table 5.4.1 summarizes some of the transects and stability classification parameters. Most of the plume profiles are represented by E or F stability. All of the transects shown in the table are from traverses offshore (airplane) or along the coast (within 3 miles). The table includes only those transects where the σ_y and downwind distance parameters could be

determined with a reasonable degree of confidence. The dynamic nature of the wind field frequently made it difficult to trace the wind trajectory of specific plume parcels. Also, the many curves in the transect routes made it difficult to interpret some of the plume plots.

Table 5.4.1

Mobile Plume Transects

σ_y /Stability Classification

Test	Traverse	Time (PDT)	Est. Downwind Trajectory Distance	Peak Tracer Value	Sigma-Y	Stability Class
1	1-16 (plane)	1613-1638	40 km	89 ppt	875 m	F
1	1-17 (plane)	1646-1706	40	98	950	F
1	1-18 (plane)	1708-1727	45	111	950	F
2	1-6 (auto)	1615-1745	70	428	1750	E/F
2	1-9 (auto)	1714-1824	70	752	2400	E
2	1-12 (auto)	1950-2007	70	231	2275	E
4	1-3 (auto)	1435-1449	7.5	8830	440	D
4	1-4 (auto)	1452-1504	13	1994	450	E/F
4	1-5 (auto)	1505-1511	10	9613	400	E
4	1-6 (auto)	1519-1525	9	5038	425	E
4	1-7 (auto)	1548-1600	7	13117	160	F
4	1-9 (auto)	1600-1612	7	9693	190	F

The plume traverses lasted from a few minutes to more than one hour. The individual data points represent a short-period sample. These samples were not corrected to a 10-minute averaging period for the stability class determination. The spatial separation of data points varied from 0.1 mile to 1 mile.

5.5 Background-Tracer Assessment

An important facet in the analysis of the tracer data involved an evaluation of the contribution of any background or fugitive sources of SF₆ to the observed tracer concentrations. This effort took on particular significance because of the essentially concurrent series of tracer experiments conducted for the Bureau of Land Management (BLM) by Aerovironment in the Ventura airshed. Other sources may also contribute to the baseline SF₆ values. In the following paragraphs we will examine the potential contribution to the baseline SF₆ from the BLM tracer releases as well as other sources.

Perhaps the best method to detect the background or fugitive plume is to examine the observed concentrations over the network during the period just prior to the start of the release through the first few hours of the test. During the period the position of the test plume is reasonably well known. Any SF₆ observed within the network but outside of the test plume can be attributed to background or fugitive sources.

Tables 5.5.1 through 5.5.6 present the observed concentrations of SF₆ during the early hours (before the plume arrival for most stations) of each test. Although the sample record is not complete (due to staggered startup of stations) sufficient samples were available to identify significant contributions to the baseline level sources of SF₆ other than the test plume.

Briefly, Tables 5.5.1 through 5.5.6 show that the baseline SF₆ was not detectable during Test 1. Small amounts of tracer (<10 pptv) were observed near El Capitan and Gaviota Pass prior to the release in Test 2. SF₆ was detected at most sample stations in Test 3. However, the observed concentrations were generally less than 10 pptv. The baseline for Test 4 showed a significant change from the earlier tests. SF₆ was observed throughout the network with many values greater than 20 pptv. The Santa Paula Station observed the highest value at 39 pptv. It should be noted that the Test 4 release began at 1240 PDT. However, most if not all of the 1200 (one hour) samples would not have been influenced by the test plume. SF₆ was observed at only a few sampling locations in the initial hours of Test 5. The Camarillo sampling station recorded a value of 26 pptv one hour before the release. However, this reading was more the exception than the rule. The observations of baseline SF₆ values for Test 6 were relatively uniform throughout the sampler network. The observed concentrations were generally about 10 pptv.

A list of possible background or fugitive sources of SF₆ would include:

- o BLM - Aerovironment tracer tests
- o "Leftover" tracer from previous Cal Tech-MRI tests
- o Utility substations
- o Natural background
- o Other sources

The following paragraphs will discuss the potential contribution of each of these sources.

The Bureau of Land Management (BLM) sponsored a tracer program conducted by Aerovironment during approximately the same time as the CARB (Cal Tech/MRI). Table 5.5.7 summarizes the dates and time periods of the BLM/AV SF₆ tracer releases. The 28 September test was a cooperative test between the two groups. The other three tests were run during off days of the Cal Tech/MRI releases. The BLM/AV tracer release points were all located about four to five miles offshore from the Ventura/Oxnard area. The release rates were approximately 50 lb/hr during the late morning through afternoon period. It is quite possible that some of the tracer released during the latter portion of the test did not clear the basin before the reversal of the diurnal flow to offshore. The return flow could bring SF₆ laden air back into the inland

valleys and coastal Ventura area where it may remain until the onset of the seabreeze the following day. The incomplete ventilation of SF₆ from the air basin could be caused by the lateness (in the afternoon) of the tracer release or by the occurrence of a weak seabreeze flow. In the latter case the SF₆ could persist in the basin in decreasing concentration levels for more than one day. During the initial return flow the SF₆ might appear in "pockets" in the coastal valleys or at selected locations along the coast. If the plume is present on subsequent days it is more likely to be more areawide and lower in concentration than on the second day. It is suggested that some of this phenomena may have occurred during the period from Test 3 through 6.

The scenario just described can also be applied to suggest that some of the tracer released during earlier Cal Tech/MRI tests may contribute to the baseline SF₆.

A tracer test was conducted nearly every day either jointly or separately by one of the two groups during the period of 24 September through 1 October. The release rates during each test were at least 50 lb/hr. The almost every day frequency of tests did cause one clear case of plume overlay. The automobile transects on day 2 of Test 3 extended into the release period of the 27 September BLM/AV test. The high concentration observed on transects 2-11 and 2-12 east of Ventura were probably from the BLM/AV plume.

The most common use of SF₆ (excluding tracer studies) is in transformers at some utility substation. If the transformer were to leak SF₆ it would be considered a fugitive source. That could bias the results of a nearby sampling station during certain meteorological conditions. If the "leaking" substation were upwind from a sampling station the bias in the sampling results would be most easily detected because of the sharp departure from observed concentration gradient patterns. Otherwise, the substation contribution would be very difficult to detect. Based on Tables 5.5.1 through 5.5.6 it does not appear that the observed concentrations of SF₆ are due to utility substation contribution or could not be better explained by an alternative source.

Another possible source of SF₆ in the test area might be industrial sites that manufacture or transfer (tank to cylinder) SF₆. However, the authors are not aware of any such sites in the test area.

SF₆ was selected as the tracer material for these transport and diffusion experiments because of its low natural background concentration and its similarly low analytical detectable limit. The natural background concentration of SF₆ has been measured at 0.25 pptv (Singh et al. 1977). The analytical detectable limit for most field laboratory instruments is near 1 pptv of SF₆. Given the concentrations of SF₆ observed during the field experiments the natural background would make no significant contribution.

The intensive release of SF₆ by the BLM/AV and ARB Cal Tech/MRI field crews increased the baseline value of SF₆ during portions of the test period. In isolated cases the baseline was 30 pptv while in most cases it was less than 10 pptv. Relative to peak centerline concentrations these values are quite small and can generally be ignored during the analysis phase. However, the analysis of off centerline concentration data and second day results may have to consider the contribution of the baseline SF₆ values for a given test.

Table 5.5.1
SF₆ Tracer Sampler Data
Background Assessment
Test 1
17 September 1980
Tracer Release 1100-1600 PDT
(Pt. Conception-10.6 g m/sec)

SF₆ Tracer Data (ppt)

<u>Station</u>	<u>Time (PDT)</u>			
	<u>1000</u>	<u>1100</u>	<u>1200</u>	<u>1300</u>
Camarillo	*	*	*	*
Carpenteria	*	0	0	0
El Capitan	0	0	0	0
Gaviota Pass	*	0	0	0
Ojai	*	*	*	*
Oxnard	*	*	0	0
Pasadena	*	*	*	*
Piru	*	*	*	*
Santa Barbara	*	*	0	0
Santa Paula	*	*	*	*
Santa Susana	*	*	*	*
Santa Ynez	0	0	3	0
Thousand Oaks	*	*	*	*
Ventura	*	*	*	2

*No SF₆ data available.

Table 5.5.2
SF₆ Tracer Sampler Data
Background Assessment
Test 2
22 September 1980
Tracer Release 1100-1600 PDT
(3 mi S of Pt. Conception-8.8 g m/sec)

SF₆ Tracer Data (ppt)

<u>Station</u>	<u>0900</u>	<u>1000</u>	<u>Time (PDT)</u>		<u>1200</u>	<u>1300</u>
			<u>1100</u>			
Camarillo	*	*	*		0	0
Carpenteria	*	*	0		9	3
El Capitan	12	6	12		5	0
Gaviota Pass	*	3	6		1	27
Ojai	*	*	*		*	*
Oxnard	*	*	*		0	0
Pasadena	*	*	*		*	*
Piru	*	*	*		*	*
Santa Barbara	*	*	0		0	0
Santa Paula	*	*	*		*	*
Santa Susana	*	*	*		*	*
Santa Ynez	*	*	0		0	0
Thousand Oaks	*	*	*		*	*
Ventura	*	*	*		0	2

*No SF₆ data available.

Table 5.5.3

SF₆ Tracer Sampler Data

Background Assessment

Test 3

26 September 1980

Tracer Release 0200-0700 PDT

(Platform Hondo-7.7 g m/sec)

SF₆ Tracer Data (ppt)

Station	Time (PDT)			
	0000	0100	0200	0300
Camarillo	4	17	7	2
Carpenteria	*	*	*	*
El Capitan	*	5	0	8
Gaviota Pass	0	2	0	4
Ojai	3	0	0	0
Oxnard	2	0	0	8
Pasadena	*	*	*	*
Piru	5	10	4	10
Santa Barbara	0	6	1	3
Santa Paula	*	*	*	*
Santa Susana	*	*	*	*
Santa Ynez	1	0	0	0
Thousand Oaks	7	5	6	10
Ventura	4	*	0	0

*No SF₆ data available.

Table 5.5.4
 SF₆ Tracer Sampler Data
 Background Assessment
 Test 4
 28 September 1980
 Tracer Release 1240-1900 PDT
 (4 mi W of Ventura-6.2 g m/sec)

SF₆ Tracer Data (ppt)

<u>Station</u>	<u>Time (PDT)</u>			
	<u>1200</u>	<u>1300</u>	<u>1400</u>	<u>1500</u>
Camarillo	0	8	12	0
Carpenteria	8	17	5	4
El Capitan	*	*	*	*
Gaviota Pass	*	*	*	*
Ojai	29	12	23	14
Oxnard	10	22	7	19
Pasadena	6	0	2	0
Piru	17	16	12	14
Santa Barbara	*	*	*	*
Santa Paula	39	58	22	31
Santa Susana	8	11	12	0
Santa Ynez	*	*	*	*
Thousand Oaks	12	6	3	1
Ventura	31	45	31	14

*No SF₆ data available.

Table 5.5.5
 SF₆ Tracer Sampler Data
 Background Assessment
 Test 5
 1 October 1980
 Tracer Release 0600-1100 PDT
 (Platform Grace-5.8 g m/sec)

SF₆ Tracer Data (ppt)

Station	Time (PDT)			
	1500	0600	0700	0800
Camarillo	26	20	8	9
Carpenteria	*	6	1	24
El Capitan	*	*	*	*
Gaviota Pass	*	*	*	*
Ojai	*	*	0	3
Oxnard	4	9	17	16
Pasadena	*	*	*	*
Piru	*	*	0	10
Santa Barbara	*	12	40	10
Santa Paula	*	*	0	0
Santa Susana	*	*	3	2
Santa Ynez	*	*	*	*
Thousand Oaks	*	*	8	3
Ventura	0	9	6	5

*No SF₆ data available.

Table 5.5.6
 SF₆ Tracer Sampler Data
 Background Assessment
 Test 6
 3 October 1980
 Tracer Release 0045-0545 PDT
 (4 mi SW of Port Hueneme-8.3 g m/sec)

SF₆ Tracer Data (ppt)

Station	Time (PDT)			
	0000	0100	0200	0300
Camarillo	0	5	0	0
Carpenteria	10	6	9	19
El Capitan	*	*	*	*
Gaviota Pass	*	*	*	*
Ojai	6	9	19	11
Oxnard	3	5	0	6
Pasadena	*	*	*	*
Piru	4	4	6	11
Santa Barbara	8	13	9	15
Santa Paula	12	12	11	14
Santa Susana	4	*	0	11
Santa Ynez	*	*	*	*
Thousand Oaks	8	0	6	16
Ventura	10	14	8	10

*No SF₆ data available.

Table 5.5.7
Summary of BLM Tracer Tests

<u>Test</u>	<u>Date</u>	<u>Release Location</u>	<u>Release Period (PDT)</u>	<u>Release Rate (gm/sec)</u>
1	9/24/80	4-5 mi west of Ventura/Oxnard	1135-1900	6.2
2	9/27/80	4-5 mi west of Ventura/Oxnard	1107-1815	6.4
3	9/28/80	4-5 mi west of Ventura/Oxnard	1243-1900	6.1
4	9/29/80	4-5 mi west of Ventura/Oxnard	1143-1900	6.0

Source: Schacher, G. E., et. al. 1982, California Coastal Offshore Transport and Diffusion Experiments - Meteorological Conditions and Data, prepared for Outer Continental Shelf Office - Mineral Management Service.

5.6 Carryover of Ozone in the Basin

Evidence from the tracer tests indicates that some of the tracer material remained in the Basin on the day following the release. The two exit routes for such material are upslope flow and offshore southward along the coast. During periods of warm temperatures aloft, in the summer, the seabreeze ends about 19 PDT and that route becomes ineffective until the following morning. Under conditions of offshore pressure gradients (higher pressure inland), such as experienced from September 29 to October 2, winds in the eastern part of the channel tend to come from the southeast during the night so that the second exit route may not be very effective. It is not unreasonable to expect, therefore, that the daily ventilation of the Basin may, on occasion, be insufficient to remove all of the pollutant burden generated for that day.

For an investigation of potential carryover of ozone in the Basin, it is useful to look at those sampling stations which are as far removed from local sources as possible. These include Pt. Conception, the offshore platforms and South Mt. whose environment is frequently not connected to surface layers in the valley. Ozone characteristics in terms of daily minimum, maximum and average ozone concentration are given in Tables 5.6.1 and 5.6.2. Minimum values, in the absence of local NO_x sources, provide an estimate of the general background level of the station. Maximum values indicate the arrival of an ozone pulse from some non-local source. Average values give some indication of how important the pulse was on that day.

Comments on the four sampling stations follow:

Pt. Conception

Two periods of ozone transport to Pt. Conception are shown, September 22-24 and September 29 to October 4. The minimum ozone level was not influenced until October 1 when successive days through October 5 show elevated background levels. The first major impulse affecting this interval occurred on September 30 when a maximum value of 14 pphm was observed. Significant inputs also occurred on October 2-4. The general background level increased to 7 pphm on October 3 and 4. All of the pulses occurred with easterly winds.

Platform Hondo

Background levels at Platform Hondo were similar but slightly lower than at Pt. Conception except for occurrences of 1 and 0 pphm on several days. These low values suggest reduction of the ozone by NO_x sources, either locally from the platform or transported offshore in the typical northeasterly flow which occurs during the night.

The principal ozone impulse at Platform Hondo started on September 30 and continued through October 2. No ozone data were available after that date. There is also a suggestion that the background level increased by October 2 but it is not conclusive. The average ozone value on October 2, however, was substantially higher than on any other day during the observational period. The impulses on September 30 to October 2 arrived during or shortly after east to southeast winds had occurred.

Table 5.6.1

Offshore Ozone Characteristics (pphm)

		Pt. Conception			Platform Hondo		
		<u>Min</u>	<u>Ave</u>	<u>Max</u>	<u>Min</u>	<u>Ave</u>	<u>Max</u>
September	17	3	3.7	6			
	18	-	-	-			
	19	3	3.0	3			
	20	3	3.1	4	0	2.6	5
	21	3	3.7	4	2	2.9	4
	22	3	4.5	8	3	4.0	6
	23	3	5.1	7	2	4.3	6
	24	4	4.8	7	3	4.0	6
	25	3	3.9	5	2	3.3	6
	26	3	3.6	4	2	3.4	6
	27	2	3.5	4	1	3.0	5
	28	3	3.9	4	1	3.0	5
	29	3	4.9	7	1	3.8	5
	30	2	6.1	14	2	4.7	9
October	1	4	6.0	8	2	4.9	8
	2	5	7.5	11	4	7.3	10
	3	7	9.0	12			
	4	7	8.7	12			
	5	5	6.5	7			
	6	2	3.9	6			

Table 5.6.2

Offshore and Elevated Ozone Characteristics (pphm)

		Platform Grace			South Mt.		
		<u>Min</u>	<u>Ave</u>	<u>Max</u>	<u>Min</u>	<u>Ave</u>	<u>Max</u>
September	17	4	5.0	7	3	6.1	10
	18	2	3.4	4	4	6.4	8
	19	3	4.1	5	2	7.1	8
	20	2	4.8	9	4	8.4	11
	21	4	4.9	6	4	8.0	10
	22	4	6.3	10	6	9.4	12
	23	4	6.8	10	6	7.6	11
	24	5	7.3	9	6	7.4	10
	25	4	6.0	7	6	9.2	16
	26	3	5.0	7	6	8.9	14
	27	2	4.7	6	6	8.2	10
	28	3	4.7	8	7	8.7	12
	29	2	4.7	8	6	7.8	10
	30	0	4.7	9	6	6.6	10
October	1	2	4.6	8	6	8.0	12
	2	1	9.0	14	6	8.3	12
	3	5	9.5	13	5	10.0	18
	4	7	9.8	11	8	15.6	25
	5	7	9.8	9	12	15.2	18
	6	6	8.1	8			

Table 5.6.2 shows the ozone characteristics at Platform Grace and at South Mt. At Platform Grace there were two periods of ozone impulses, September 22-24 and October 2-5. The first period was associated with south-westerly winds, the second with south to southeasterly wind directions. Through September 28, the background levels correspond reasonably well with the ground levels to be expected in the offshore area. From September 29 to October 2 the minimum observed ozone was 2 pphm or less, suggesting the reduction of ozone by NO_x . Northeast to southeast winds associated with offshore pressure gradients suggest that land sources may have been responsible for the reduction. After October 2 the general background level increased and the average hourly concentration was greater than 9 pphm for 3 days.

The data at South Mt. show two principal periods of ozone impulses, September 25-26 and October 1-5. Background levels were higher after September 21 but increased further on October 4 and 5. Average hourly concentrations on these days were over 15 pphm.

In general there were two principal periods of ozone injection into the offshore area. The first and smaller influence was on September 22-23 and the second, more important period began about September 30. There was no appreciable influence on minimum, background levels of ozone offshore as a result of the first period. Ozone transport during the second period resulted in the highest minimum values at Pt. Conception on October 3-4 and on October 4-5 at Platform Grace and South Mt. Minimum, background levels at Pt. Conception and Platform Grace were similar during this period but were considerably higher at South Mt.

One possible scenario which could explain the above developments is the following:

1. Easterly flow at Pt. Conception reached its peak on October 2 and decreased each day thereafter. Ozone (and precursors) were transported from the coastal areas to the western part of the channel most effectively on October 2 where they were widely dispersed and raised the overall background level to 7 pphm on October 3-4.
2. The widespread reservoir of ozone over the water tended to be transported eastward in a net movement sense for the next few days as the offshore flow began to subside. The highest background levels at Platform Grace were observed on October 4-5. The background at South Mt. was highest on October 5 but decreased on October 6 as indicated by partial data recovery. Peak hourly ozone at South Mt. was observed on October 4.
3. The behavior of wind patterns and offshore ozone concentration during episode conditions (e.g., September 30 to October 5) suggests that the channel may act as a reservoir of pollutants with the effects of easterly winds at night opposing westerly flow during the daytime. Depending on the relative strength of the two flows, the ventilation of the channel may not be very efficient as whatever pollutants do escape from the Basin during the day may be replaced by new pollutants generated during the day.

One of the mechanisms for input of ozone into the reservoir is apparent from aircraft soundings. On most days relatively high ozone concentrations were measured above the mixing layer and the inversion layer. On September 28 and October 1 these ozone layers were also observed over Platform Grace with the top of the elevated layers at 500 and 200 m, respectively. These layers were apparently not connected to the surface mixing layer. An outstanding example was observed on October 3 between the San Fernando Valley and Ventura. Peak concentrations of 30 pphm were observed at 427 m-msl and 36 pphm at 710 m-msl. Highest surface ozone concentrations were 19 pphm at Moorpark and Piru.

These layers are generally lower in altitude than can be attributed to transport from the San Fernando Valley. They are believed to be associated with upslope flow along the western slopes of the coastal ridges. Once the ozone has been delivered aloft, easterly winds can carry the material westward where it may be dispersed and return with a wind shift to westerly.

The foregoing provides an hypothesis for conditions existing during ozone episodes. It needs considerable verification or refinement. Due to the complexities of the system, a well-defined tracer program is probably required for further understanding.

5.7 Ozone and Wind Characteristics - South Mt.

Wind and ozone measurements were made at South Mt. (elev. 2260 ft. msl) during the field program. South Mt. is located on the ridge immediately to the southeast of Santa Paula and offers a unique opportunity to examine the wind and ozone conditions at an elevated site. The ozone data were available from August 27 to October 6. Wind and temperature data were recorded from September 6 to October 5. In order to have a consistent data base, statistics for the latter period are discussed below.

Table 5.7.1 gives the average wind speed, most frequent wind direction and average ozone concentration for the period September 6 to October 5:

Table 5.7.1

Wind and Ozone Characteristics - South Mt.

<u>Time</u>	<u>W/D</u>	<u>W/S</u>	<u>O₃</u>
00 PST	110°	3.5 m/s	7.0 pphm
02 PST	030°	4.1 m/s	7.1 pphm
04 PST	030°	3.8 m/s	6.1 pphm
06 PST	030°	3.6 m/s	5.7 pphm
08 PST	180°	2.8 m/s	5.6 pphm
10 PST	180°	2.0 m/s	6.9 pphm
12 PST	190°	2.3 m/s	8.0 pphm
14 PST	200°	2.9 m/s	8.7 pphm
16 PST	300°	3.5 m/s	8.3 pphm
18 PST	310°	3.8 m/s	8.4 pphm
20 PST	340°	3.7 m/s	8.0 pphm
22 PST	150°	3.1 m/s	7.7 pphm

During the daytime the wind directions at South Mt. follow a directional pattern similar to the surface stations along the Ventura coast. Southerly winds in the morning are followed by a shift through west to northwest by late afternoon and evening. During the night easterly and northeasterly winds prevail in a manner similar to the surface drainage flows. Wind speeds show a late afternoon and an early morning peak in average velocity.

Average ozone concentrations show a peak in mid-afternoon, indicating the influence of the surface-based mixed layer. In contrast to the low altitude stations, however, average ozone concentrations remain relatively high during the night as the air at higher elevations becomes decoupled from the lower levels and is unaffected by nocturnal NO reactions. A major effect of this decoupling is shown in Table 5.7.2:

Table 5.7.2

Frequency of Ozone Concentration > 10 pphm

(September 6-October 5, 1980)

<u>Location</u>	<u>No. of Hours > 10 pphm</u>	<u>No. Days > 10 pphm</u>	<u>Max O₃</u>
South Mt.	86	11	25 pphm
Ojai	40	9	16 pphm
Piru	79	17	21 pphm
Simi	32	8	17 pphm

As indicated in the table, South Mt. experienced the largest number of hours with ozone concentrations greater than 10 pphm and the highest maximum ozone concentration. These, however, occurred on fewer days than at Piru. This is a direct result of the decoupling at night when there is no effective mechanism for the reduction of O₃ concentrations.

Under episodic conditions when the ventilation of the basin is relatively poor, this decoupling can lead to extended periods of high ozone aloft. This results not only from ozone produced during the day but from that day's ozone being recirculated from the inland slopes by easterly winds at night. During the period from 13 PST on October 3 to 24 PST on October 5 (total of 60 hours) there were only three hours with ozone concentrations of 10 pphm or less. Most frequent wind directions with high ozone concentrations follow the pattern given in Table 5.7.1. Northwesterly winds predominate during the afternoon with easterly winds at night. The trajectory of the ozone aloft depends strongly on the strength of the easterly flow at night. There is evidence from the aircraft soundings that the material may be carried over the channel at least as far as Platform Grace.

5.8 Flux Estimates

Pibal wind observations were made at Simi and Ojai at two-hour intervals on tracer test days. These provide the opportunity of evaluating the flux as associated with the onshore seabreeze flow which is the dominant daytime wind regime in the area.

The mean direction of the seabreeze flow appeared to be about 270° at Simi and 250° at Ojai. Component winds were calculated relative to these directions and the flux was summed over the depth of the seabreeze flow. In most cases, the top of the seabreeze flow was well defined by a reversal in wind direction to an easterly component. In a few cases, the seabreeze flow was imbedded in an overall westerly wind and the depth of the seabreeze flow was defined by directional or velocity wind shears.

Figs. 5.8.1 to 5.8.6 show time histories of the fluxes at Simi and Ojai. Units of the flux are m^2/sec . The data can also be interpreted as a volume flux for a 1m crosssection perpendicular to the wind. Data are presented for each of the tracer test days. Dashed lines represent the estimated depth of the seabreeze flow.

In general, the seabreeze flux starts between 09 and 11 PDT and ends shortly after 19 PDT. Peak flux frequently occurs between 15 and 17 PDT.

There is a considerable difference in the estimated fluxes for September 17 compared to September 22 and 26. It will be recalled that the transport velocities in the channel on September 17 were substantially larger than on September 22 and 26. This difference is reflected in the strength of the seabreeze flow. Depths of the seabreeze flow show a similar comparison. The data indicate much more rapid ventilation of the channel basin on September 17 than on the two successive test days. It is to be noted that the duration of the seabreeze was not dissimilar among the three days.

On September 28 an additional pibal observation was made at the Ventura APCD, a few miles inland from the coast. Flux magnitudes at Simi and Ojai were intermediate between September 17 and September 22/26 but the temporal characteristics were not particularly different. The flux data at Ventura APCD slightly exceed the values estimated at Simi and Ojai but not to a significant degree. It would be assumed that the seabreeze characteristics were relatively uniform from the coast inland to Simi and Ojai.

Air fluxes for September 28 at Simi and Ojai have been summed over the duration of the seabreeze to estimate the total quantity of air passing out of the basin through the inland valleys. If a crosswind distance of 50 km is assumed (from Thousand Oaks past Ojai), an average of approximately $2 \times 10^{11} \text{ m}^3/\text{hr}$ moves eastward out of the basin on the seabreeze flow. The area of the basin from Simi to Pt. Conception is approximately $6 \times 10^9 \text{ m}^2$. If the seabreeze draws from a layer 300 m deep, the appropriate volume would be $1.8 \times 10^{12} \text{ m}^3$. It would thus require about nine hours to ventilate the entire basin which is about the normal duration of the seabreeze.

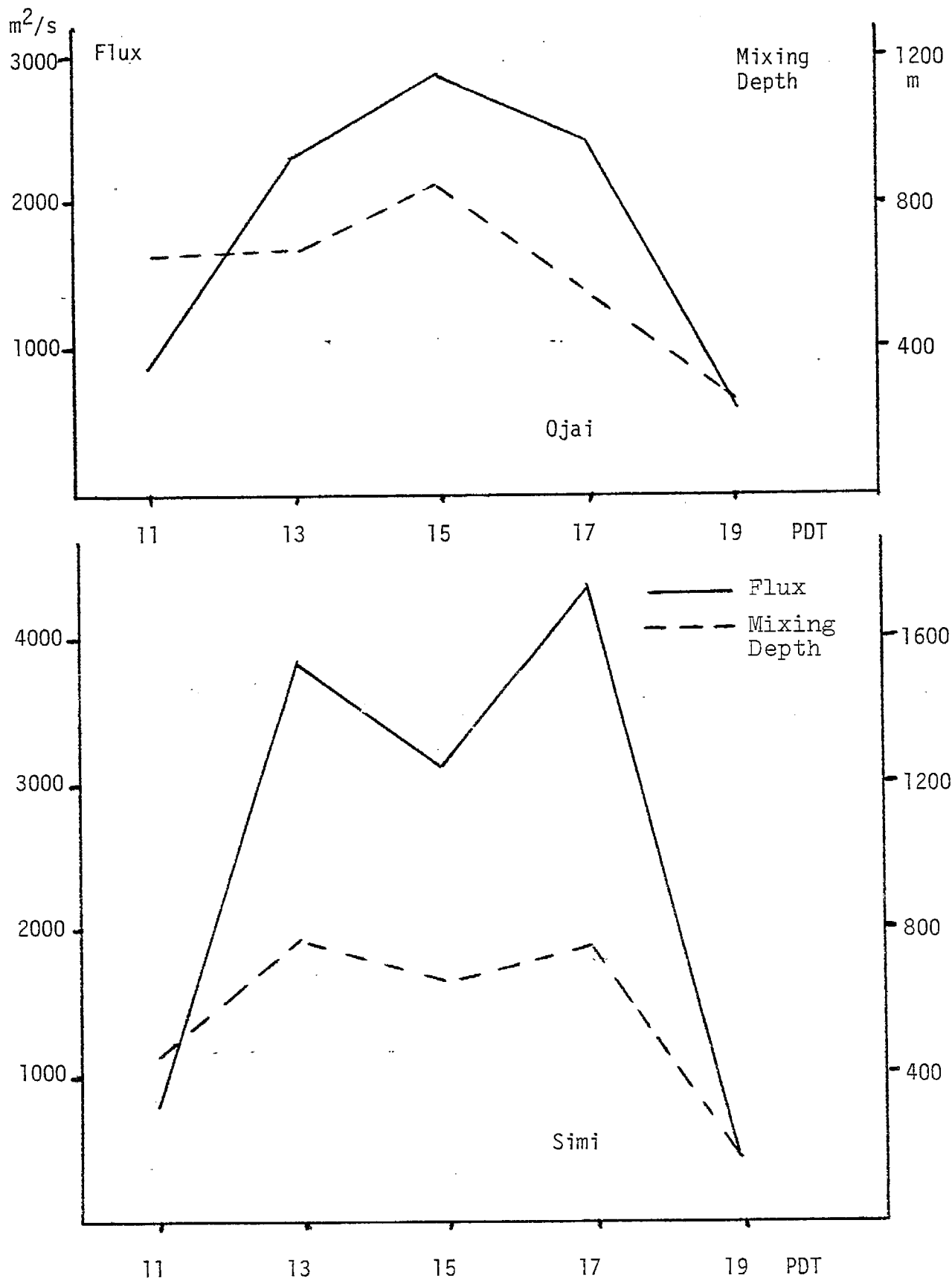


Fig. 5.8.1 ONSHORE FLUX ESTIMATES - September 17, 1980

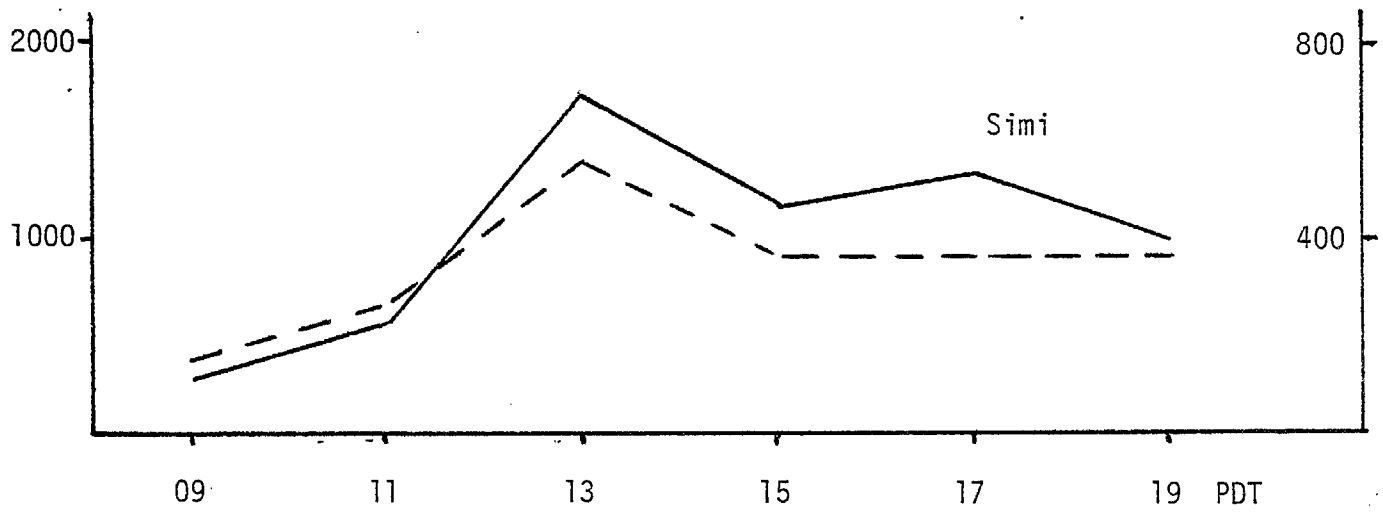
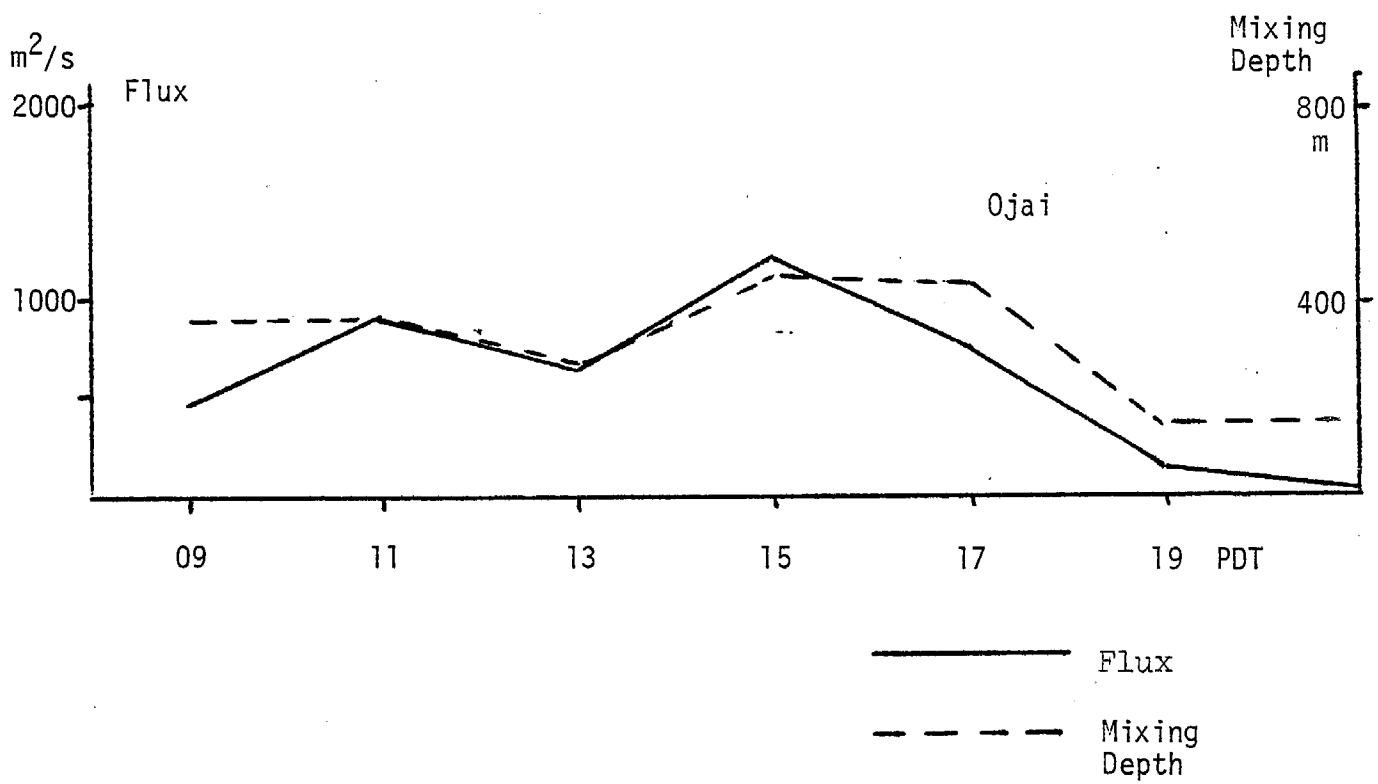


Fig. 5.8.2 ONSHORE FLUX ESTIMATES - September 22, 1980

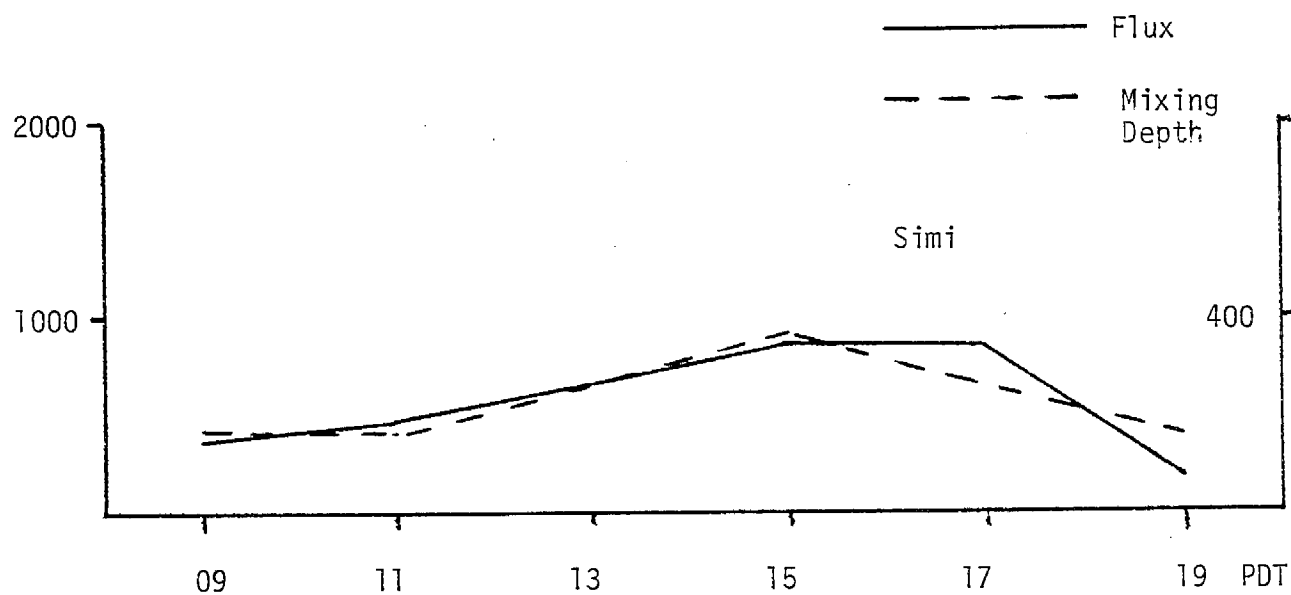
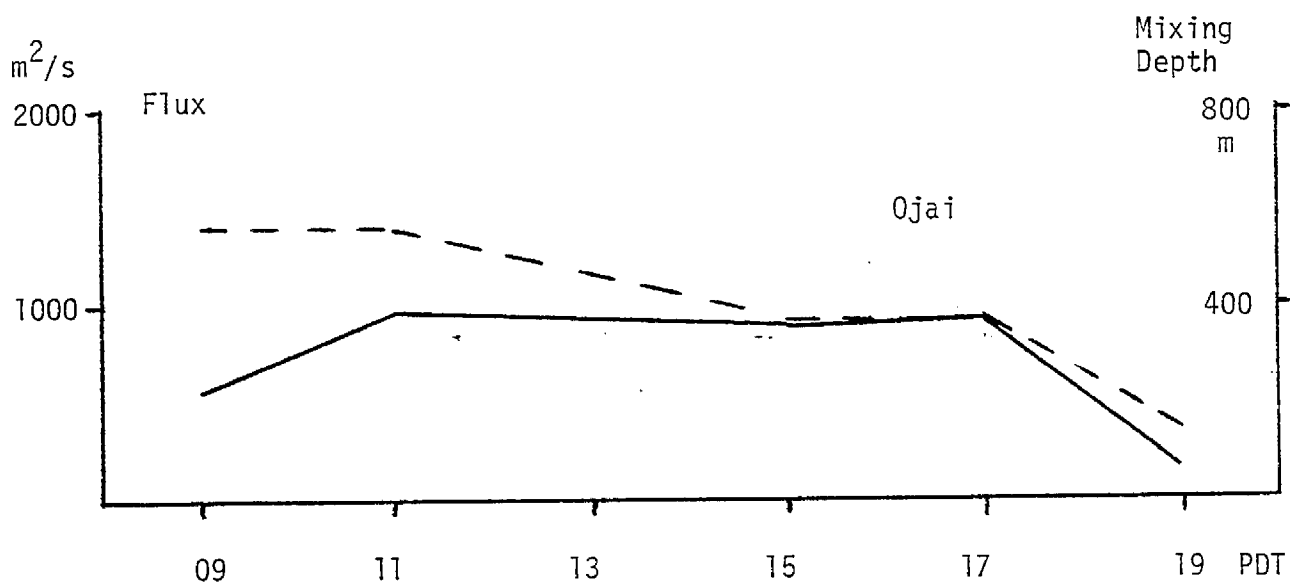


Fig. 5.8.3 ONSHORE FLUX ESTIMATES - September 26, 1980

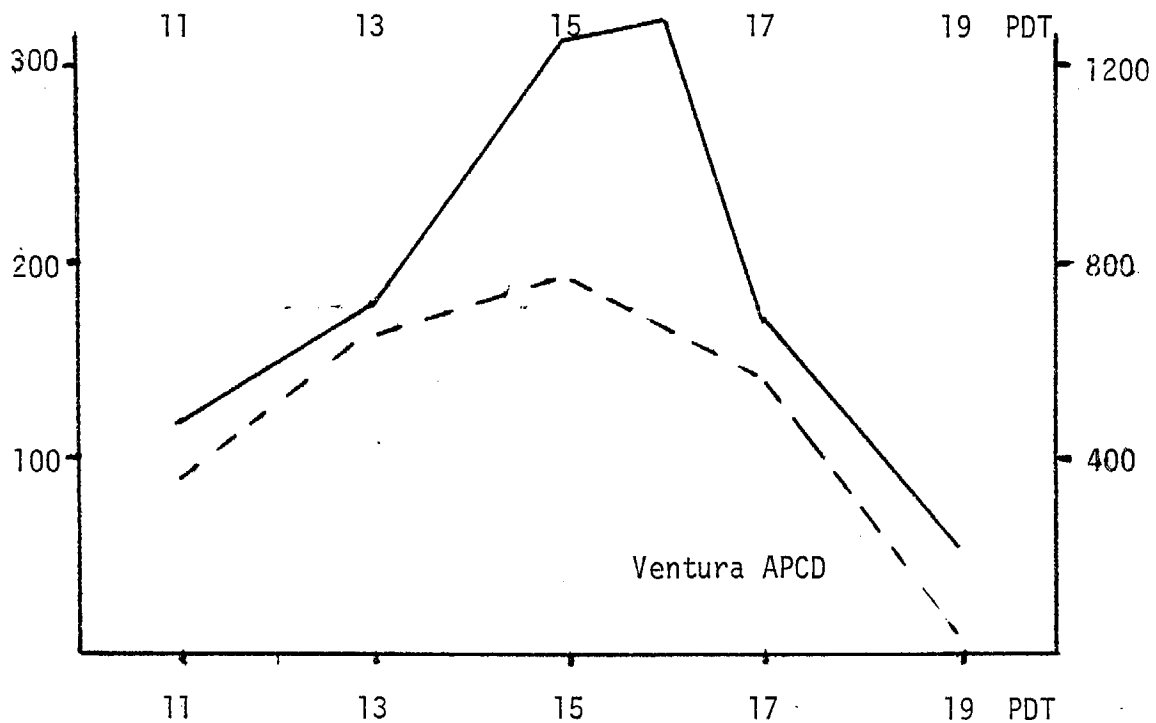
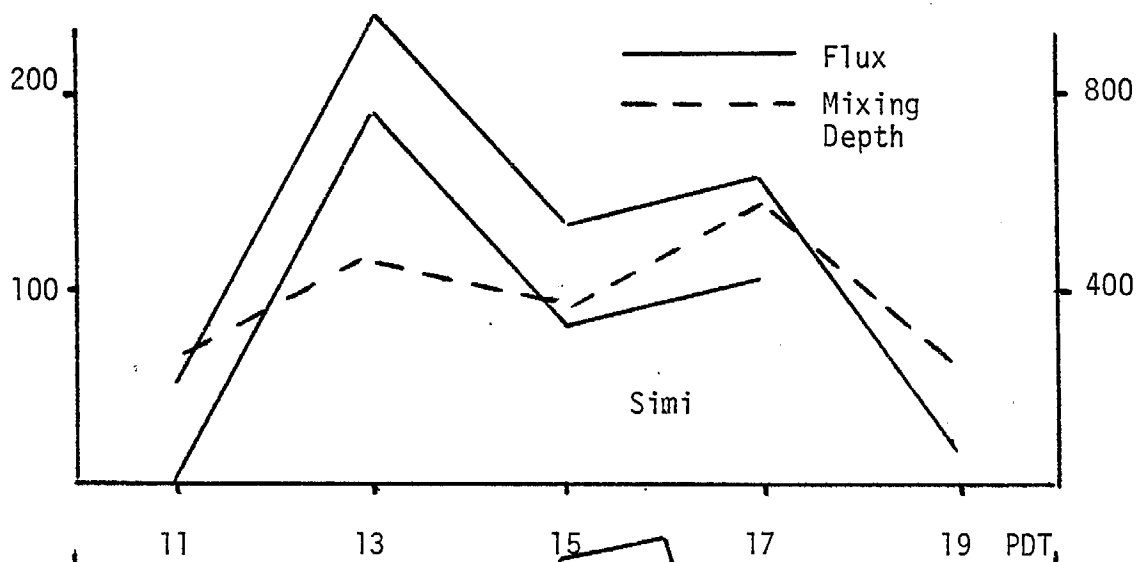
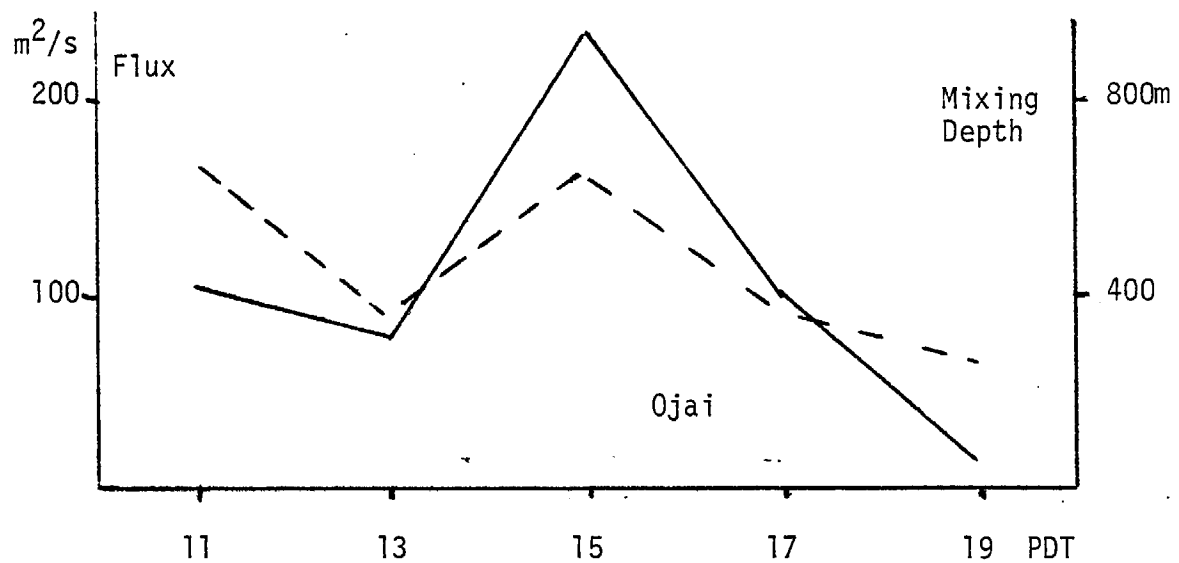


Fig. 5.8.4 ONSHORE FLUX ESTIMATES - September 28, 1980

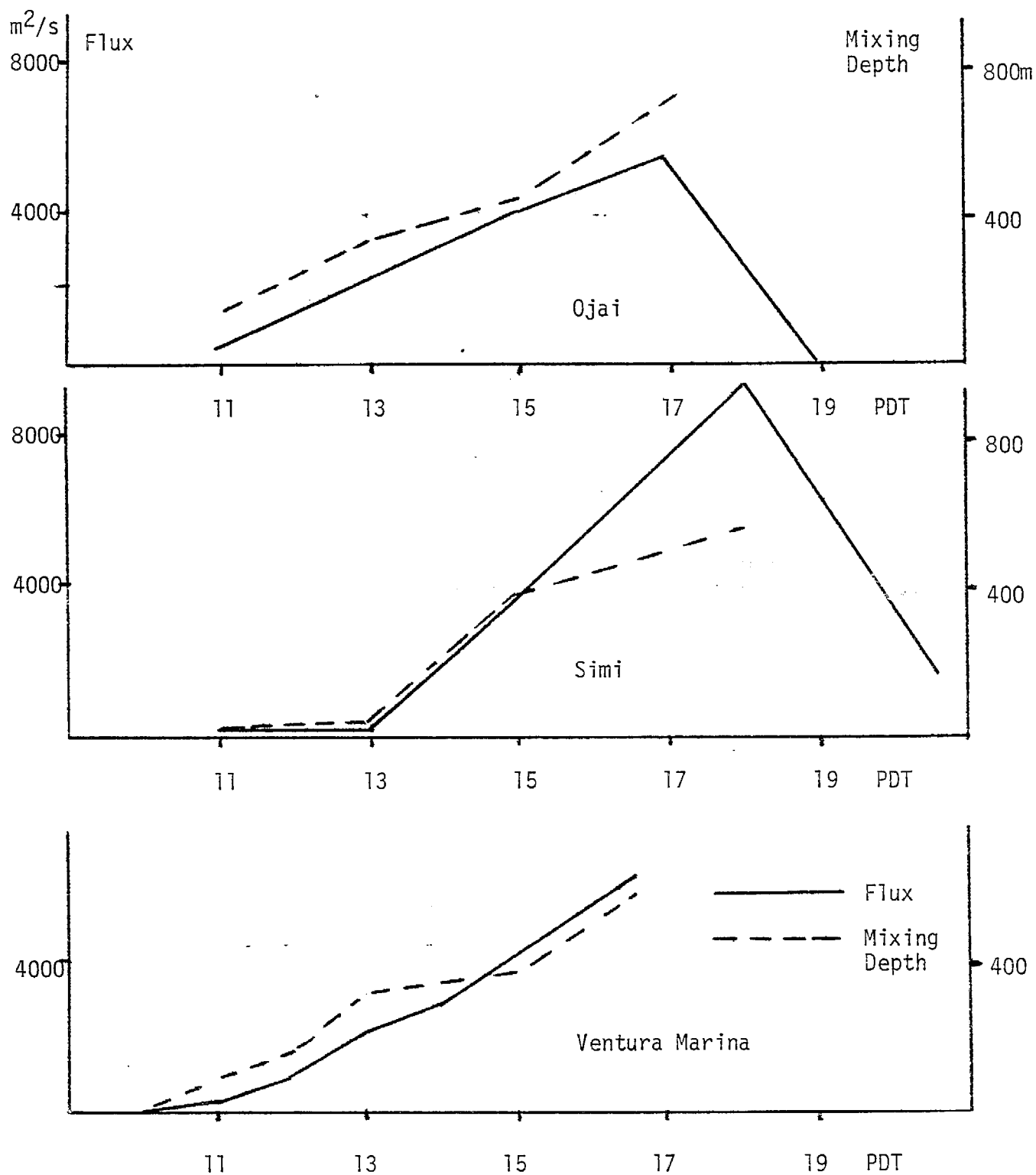


Fig. 5.8.5 ONSHORE FLUX ESTIMATES - October 1, 1980

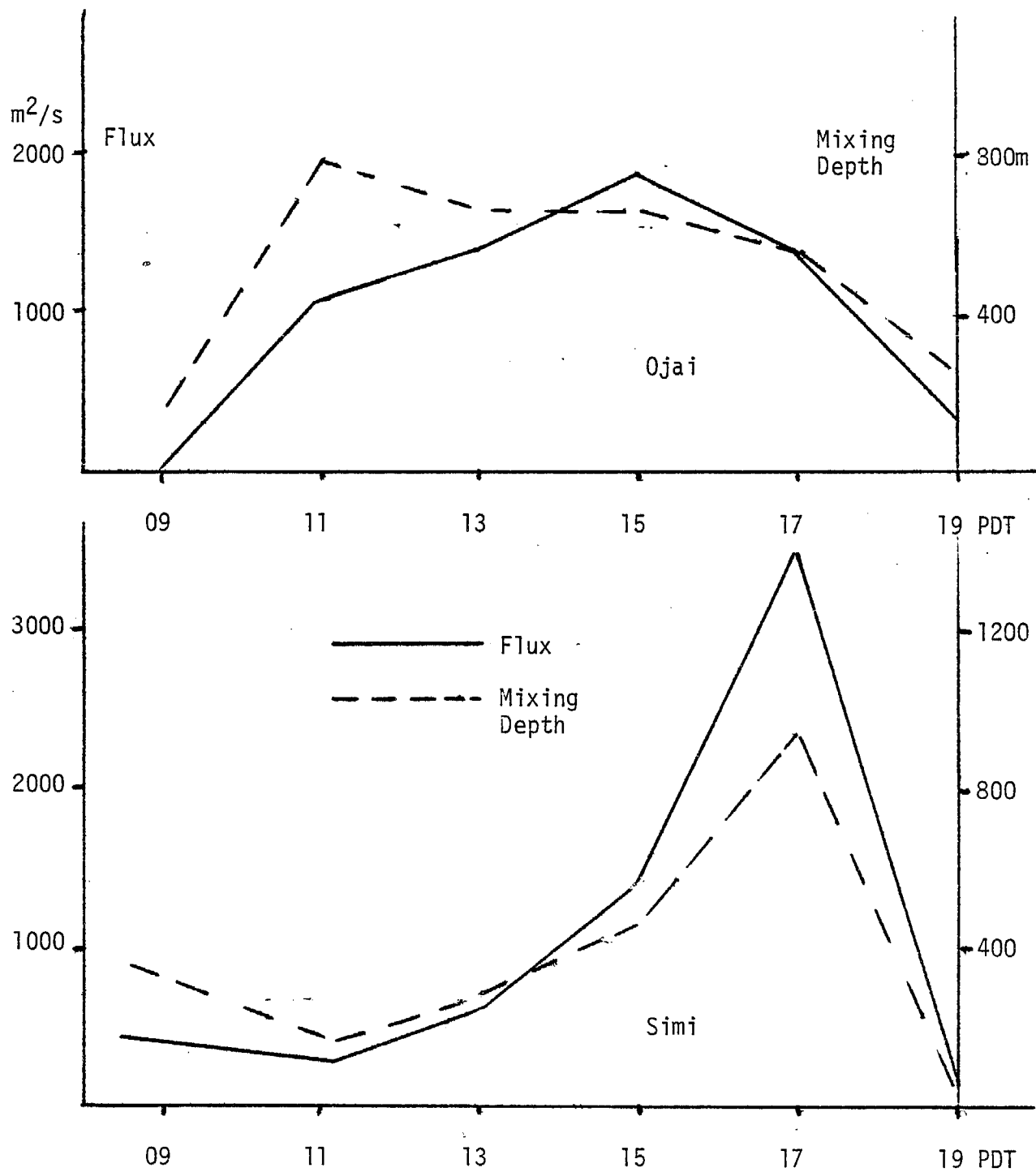


Fig. 5.8.6 ONSHORE FLUX ESTIMATES - October 3, 1980

The flux data on October 1 were quite different from the previous days. The flux increased rapidly during the afternoon at all three locations, far exceeding the flux magnitudes on any of the previous days. By 19 to 20 PDT this strong flow had collapsed at both Simi and Ojai. No later data were available from Ventura.

The cause of the strong flux on October 1 are the very warm surface temperatures which occurred in the inland areas on October 1. Piru had a maximum temperature of 108°F, Upper Ojai 111°F and Thousand Oaks had a maximum of 100°F. These were among the highest temperatures recorded during the field program. Reference to Fig. 4.6.5 shows that the strong surface heating at Ojai resulted in the formation of a deep, mixed layer which permitted the development of a deep, seabreeze flow. As indicated in Fig. 4.6.18, a major shift to a westerly wind flow occurred in the eastern part of the channel between 12 and 16 PST. It is suggested that this change was associated with the development of the strong seabreeze flux. By contrast, shallower mixed layers inland on previous tests, associated with cooler surface temperatures, limit the total seabreeze flux which can occur.

By October 3 (Fig. 5.8.6) the maximum surface temperatures at Piru had decreased to 85°F. Fluxes at Simi and Ojai were also reduced significantly to levels comparable to those found on September 28. The temporal characteristics of the fluxes also corresponded to the earlier tests.

Surface ozone data were available from Ventura, Simi and Ojai. It is assumed that the ozone concentration was constant in the mixed layer. These data can be combined with the flux data to produce estimated ozone fluxes. These estimates are given in Figs. 5.8.7 and 5.8.8. Units of the ozone flux are g per meter of crosswind distance for the flux within the seabreeze layer.

As might be expected, the characteristics of the ozone flux plots are quite similar to the air flux graphs. Higher ozone fluxes occurred on September 17 compared to September 22 and 26, due to greater air fluxes, in spite of lower ozone concentrations.

Ozone fluxes on September 28 were similar to those estimated for September 17. Fluxes calculated for Ventura were about the same magnitude as found at Ojai and Simi. Peak surface ozone concentrations were 10, 7 and 7 pphm at Ojai, Simi and Ventura, respectively, which does not suggest much ozone formation between the coast and the inland areas.

Ozone fluxes on October 1 and 3 were increased compared to previous days, primarily because of increased air flux on October 1 and higher ozone concentrations on October 3. Data for October 1 show increases in ozone flux for the inland areas compared to the coast which may relate to ozone development along the trajectory.

5.9 Potential Ozone Transport Into the Basin

Occurrences of late afternoon or evening ozone peaks along the coast at Ventura and Port Hueneme were described in the Section 4 case study days.

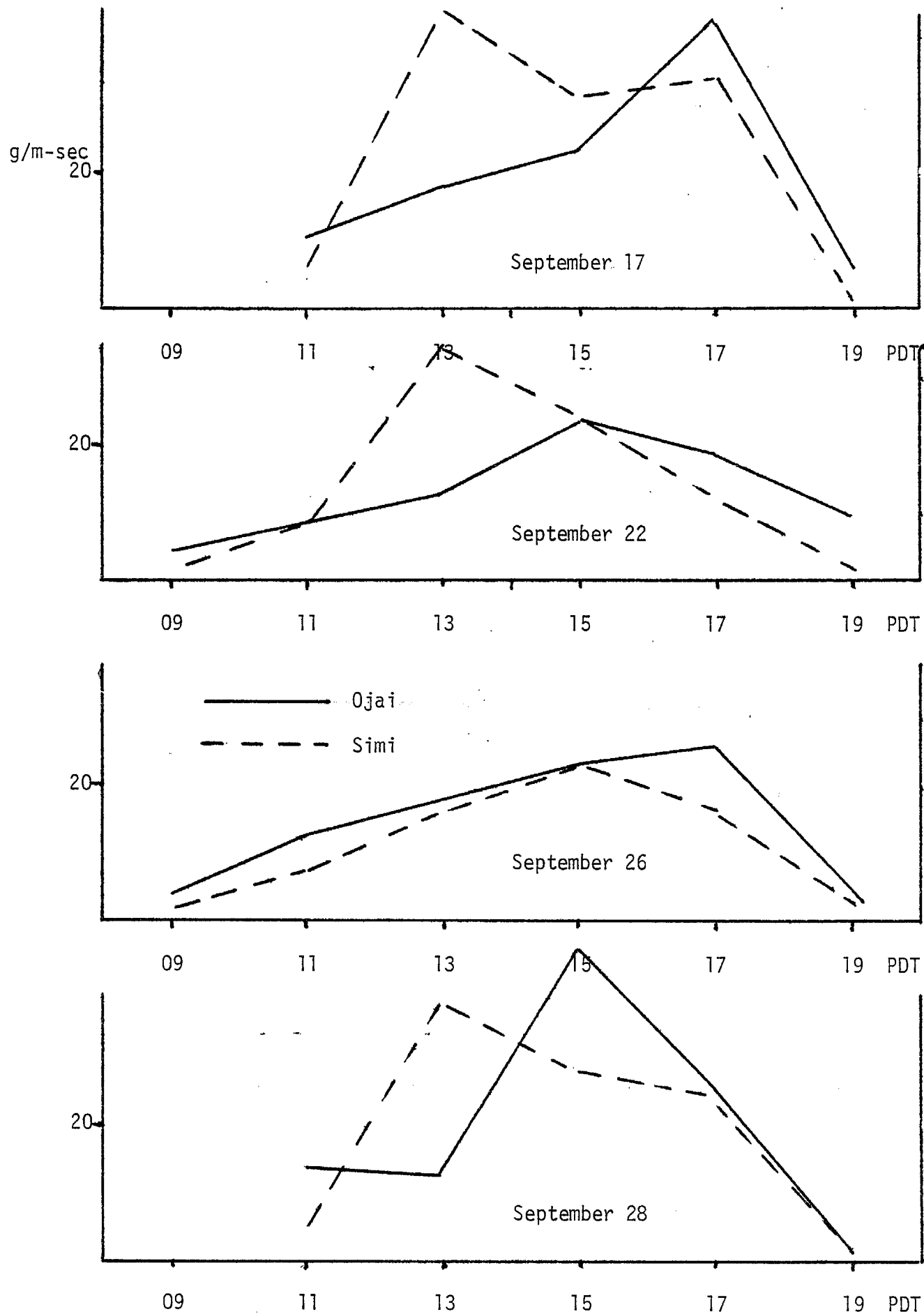


Fig. 5.8.7 OZONE FLUX ESTIMATES

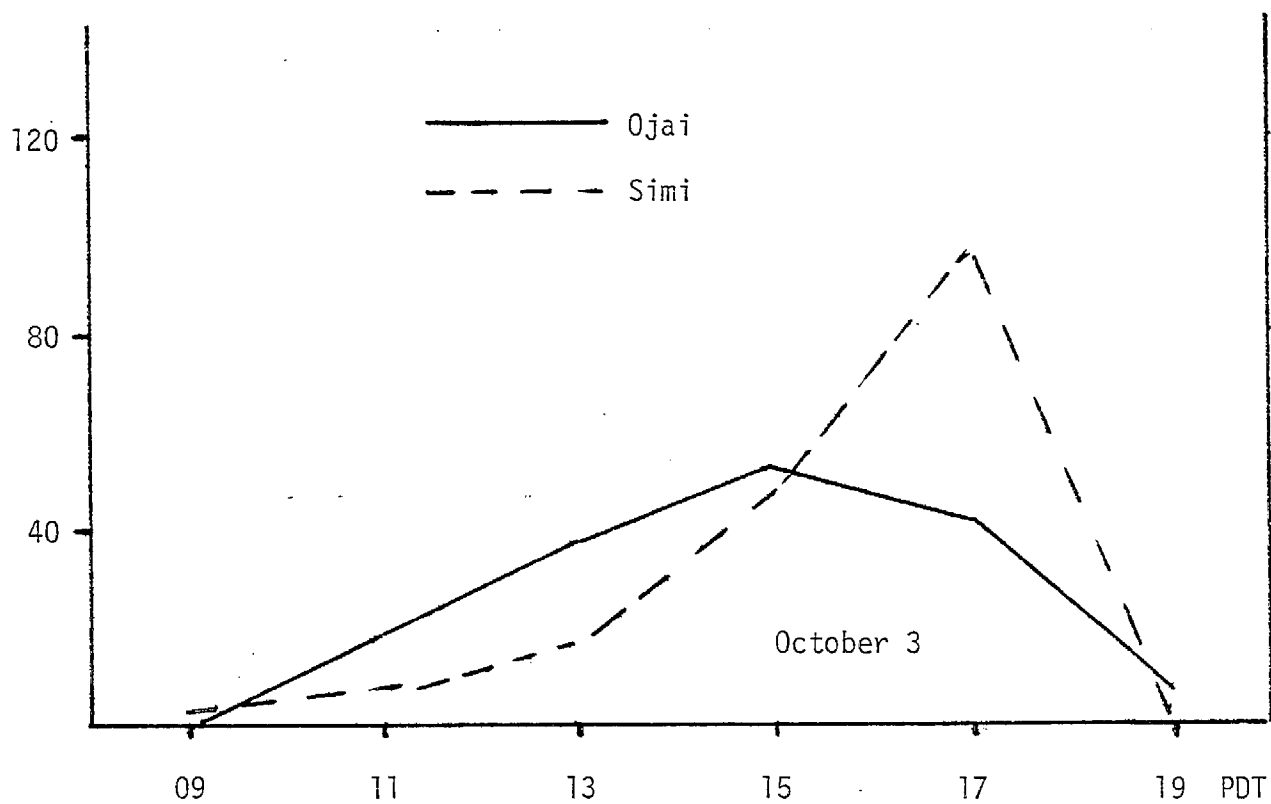
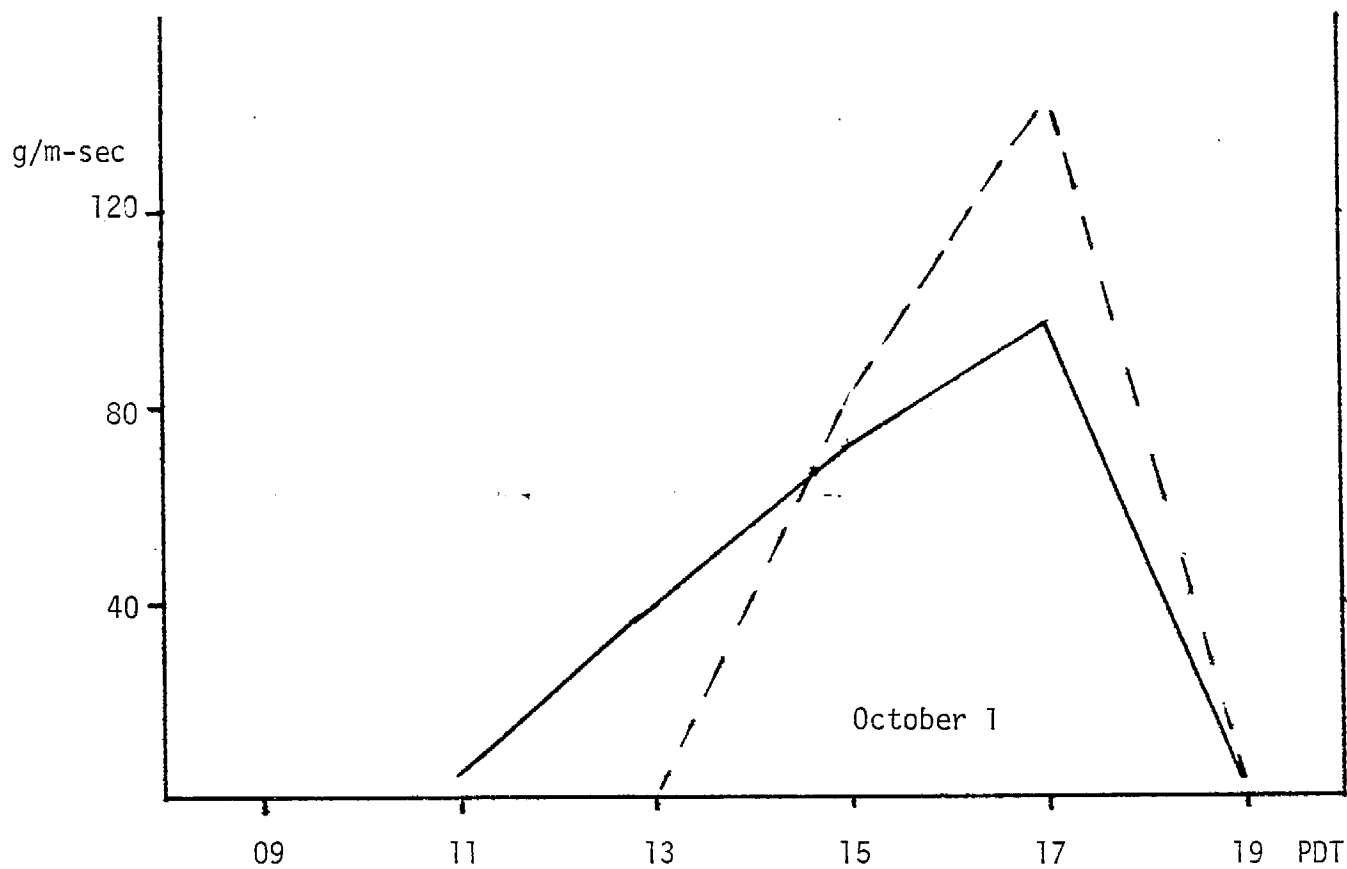


Fig. 5.8.8 OZONE FLUX ESTIMATES

Table 5.9.1 shows some late afternoon ozone characteristics observed at the two stations during the field program (September 17-October 4):

Table 5.9.1

Ozone Characteristics

	<u>Ventura</u>	<u>Port Hueneme</u>
Most frequent time of peak ozone	14-15 PST	17 PST
Peak ozone observed	13 pphm	13 pphm
Date and time of peak	2nd/14-17 PST	2nd/20-21 PST

The most frequent time for peak ozone to occur along the Ventura coast was late afternoon. Peak hourly ozone concentrations of 13 pphm recorded at Ventura and Port Hueneme followed this pattern but with the peak at Port Hueneme occurring in the early evening.

The period of the peak ozone is examined in greater detail in Fig. 5.9.1. Plots of hourly ozone concentrations for October 1-3, 1980 are shown for Ventura (Seaside Park), Port Hueneme, Ojai and Piru. The typical afternoon peaks at Ojai and Piru are clearly evident. There are indications of a midday increase also at Ventura and Port Hueneme but during the night of October 2-3, the peak at Ventura was prolonged until 17 PST and new peaks appeared at both Ventura and Port Hueneme at 21-22 PST. These later peaks were not reflected in the Ojai and Piru data. A similar pattern appears during the night of October 1-2 but with lower peak ozone values. These later peaks provide the "most frequent" characteristics shown in Table 5.9.1. The daily ozone peak occurred at 17 PST or later on 9 of 18 days at Ventura and 12 of 18 days at Port Hueneme.

Back trajectories from Ventura and Port Hueneme beginning with times of peak ozone occurrence on October 2 are shown in Fig. 5.9.2. The trajectories have been carried back two hours over the water, using observed winds along the coast and at Platform Grace. Beyond two hours the trajectories become more uncertain.

One of the most interesting features of October 2 is the ozone behavior at Platform Grace. A peak of 13 pphm occurred with southeast winds at 12 PST. Subsequently, the wind shifted to west-southwest and a second peak of 14 pphm arrived at 16 PST. The evidence is strong that the peak ozone arrived at Platform Grace on a southeasterly flow, moved northwest and was picked up in the westerly wind shift, passing back over the platform. With the observed winds, however, it is unlikely, that the late peak at the platform reached the coast before the end of the seabreeze cycle.

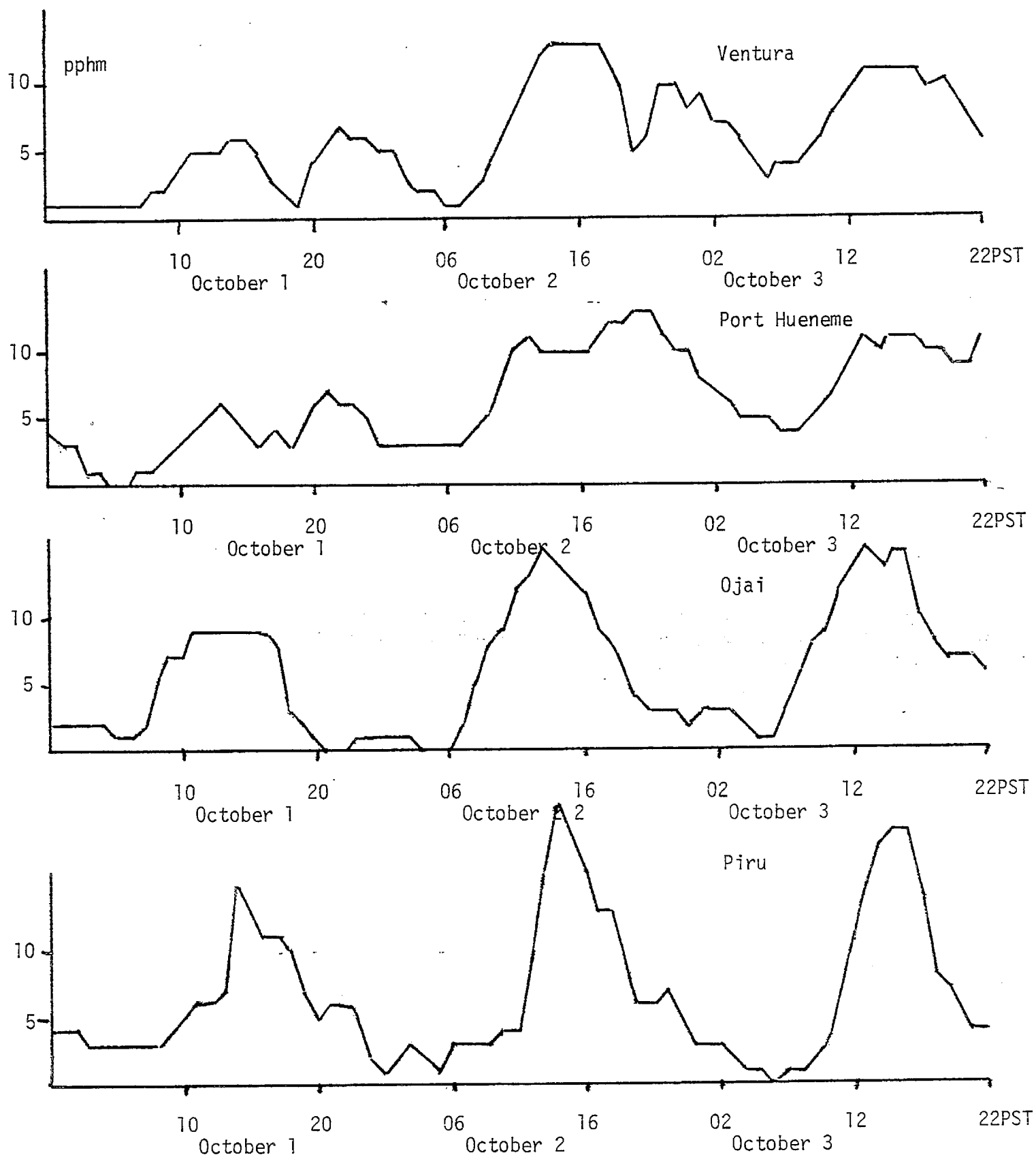


Fig. 5.9.1 HOURLY OZONE CONCENTRATIONS - October 1-3, 1980

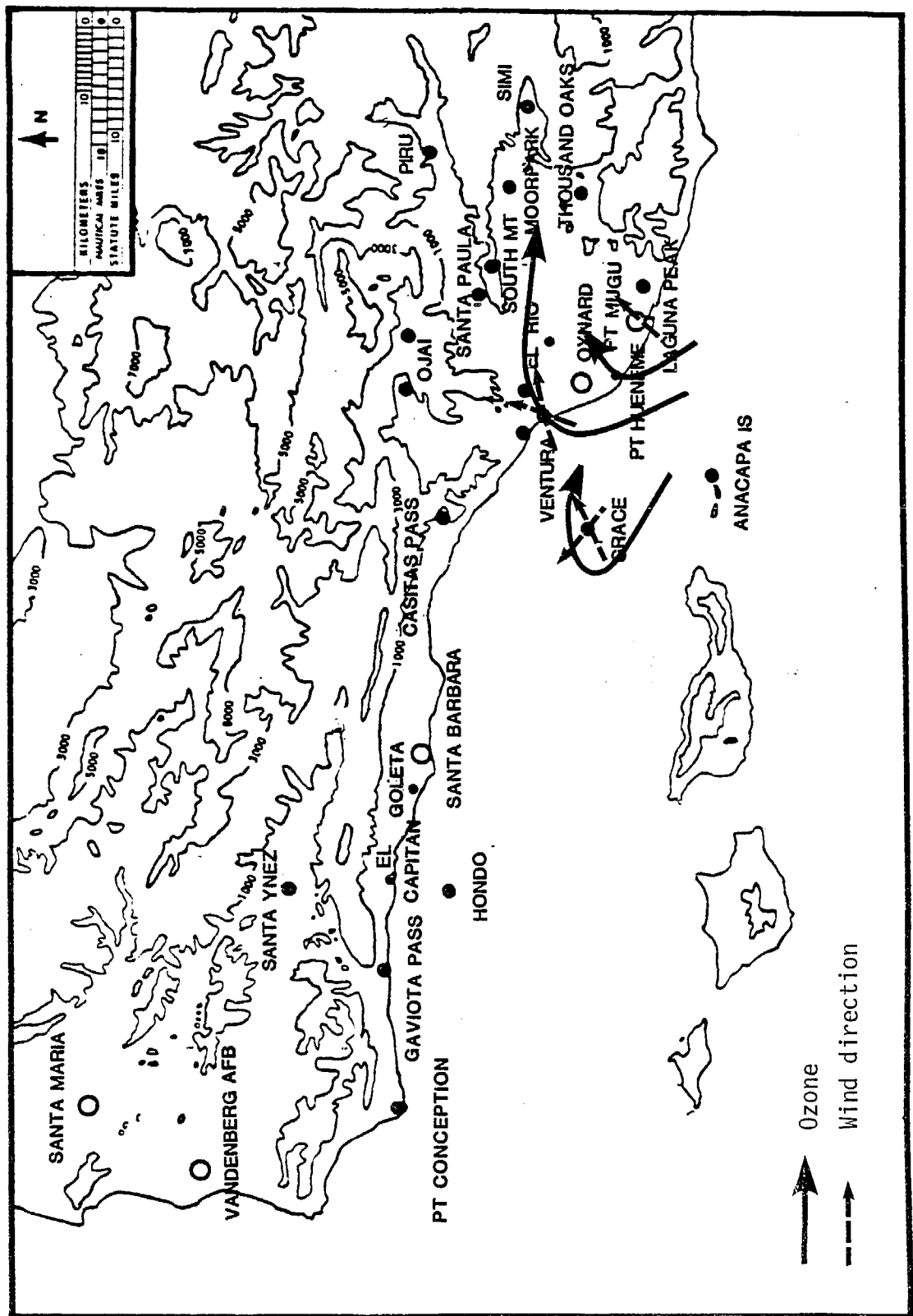


Fig. 5.9.2 OZONE TRAJECTORIES - October 2, 1980

Winds along the coast were onshore from the southwest during the later ozone peaks, having been more southerly earlier in the afternoon. The back trajectories reflect this pattern with the ozone apparently arriving from the southeast. As indicated in the figure, there was an indication from the wind patterns and ozone traces that some of the ozone cloud passing Ventura moved eastward into Moorpark and Thousand Oaks before the end of the seabreeze flow. Peak values at Moorpark and Thousand Oaks were 5 and 2 pphm, respectively, but were apparent above the normal low background at night. It is of interest to note that the peak ozone values of 13 pphm at Ventura and Port Hueneme occurred concurrently with dense fog.

The foregoing suggests transport of ozone from the southeast into the offshore area on a rather frequent basis. The source may be the South Coast Air Basin but it cannot be documented with the available data. The track followed by the tracer outlined by Shair et al. (1982) is compatible with the data described above except that the tracer arrived at Ventura somewhat earlier in the seabreeze cycle.

An alternative transport hypothesis has been proposed from the South Coast Air Basin to the Ventura area. This route is through the Simi Hills when ozone or precursors may be transported on southeasterly winds.

The most notable example of this pattern within the field program period occurred on September 28. Soundings at Santa Susana Airport and in the west San Fernando Valley showed a layer of 22-23 pphm ozone centered at about 1000 m-msl and imbedded in a layer of easterly winds. This later was observed as far west as Thousand Oaks in the late afternoon and may have been carried farther west during the evening. There is no indication that this elevated layer had any influence on surface ozone concentrations in the South Central Coast Basin. Such a hypothesis requires a physical mechanism for transport to the surface which is not readily apparent. The ozone aloft exists in a relatively warm layer of air. The cool marine air near the surface along the coast results in stable, vertical temperature gradients which are not conducive to transport of the ozone to the surface. A tracer experiment will be needed to determine whether this transport takes place effectively.

5.10 Vertical Structure Over Water

Eleven vertical soundings were made over the water by the air quality aircraft during the field program. These were carried out on four different days. These data permit an examination of the vertical structure of the lower levels of the atmosphere over the water which is of great interest in defining dispersion conditions.

The eleven soundings are summarized in Table 5.10.1. Plots of each of the soundings have been previously presented in Section 4 and are not repeated. Figure numbers and page numbers are provided for easy reference.

Table 5.10.1

Summary of Mixing Layer Depths Over Water

	<u>Time</u> (PDT)	<u>Location</u>	<u>Layer</u> <u>Depth</u> (m)	<u>Figure</u> <u>No.</u>	<u>Page</u>
9/17/80	1353	Off Pt. Conception	150	4.2.3	
	1416	Off Gaviota	100	4.2.4	
	1834	Off Santa Barbara	100	4.2.10	
9/22/80	1318	Off Pt. Conception	500	4.3.3	
	1344	Off Gaviota	250	4.3.4	
	1741	Off Santa Barbara	400	4.3.10	
9/28/80	1410	Off Platform Grace	100	4.5.5	
10/1/80	1341	Off Ventura	300	4.6.3	
	1449	Off Platform Grace	100	4.6.7	
	1707	Off Ventura	100	4.6.12	
	1857	Off Santa Barbara	400	4.6.16	

Mixing layer depths for each of the soundings are given in the table. These were determined from the profile characteristics of temperature, turbulence, moisture and air quality parameters. No single parameter provided a distinguishing characteristic although temperature and turbulence profiles were probably of greatest significance. Depths of the mixing layer in the table range from 100 to 500 m.

A number of other programs of a somewhat similar nature have been conducted recently offshore of the California Coast. The programs were sponsored by the Bureau of Land Management and were carried out by the U.S. Navy Post-Graduate School (Schacher et al., 1982) by AeroVironment (Zannetti et al., 1981) and by Stanford Research Institute (Brodzinsky et al., 1982). Of particular importance were a large number of detailed radiosonde observations made from offshore locations by the USNPS group on the R/V Acania. These soundings were processed into definitions of the mixing layer depth and have been summarized in a USNPS publication (Schacher et al., 1982). The range of mixing layer depths observed during each program is summarized in Table 5.10.2:

Table 5.10.2

Mixing Layer Depth Measurements - NPS

<u>Location</u>	<u>Date</u>	<u>Mixing Layer Range (m)</u>	<u>Median Layer Depth (m)</u>
Santa Barbara Channel	September 1980	5 to 800	230
Santa Barbara Channel	January 1981	5 to 570	150
Pismo Beach	December 1981	5 to 1270	140
Pismo Beach	June 1982	90 to 1380	600

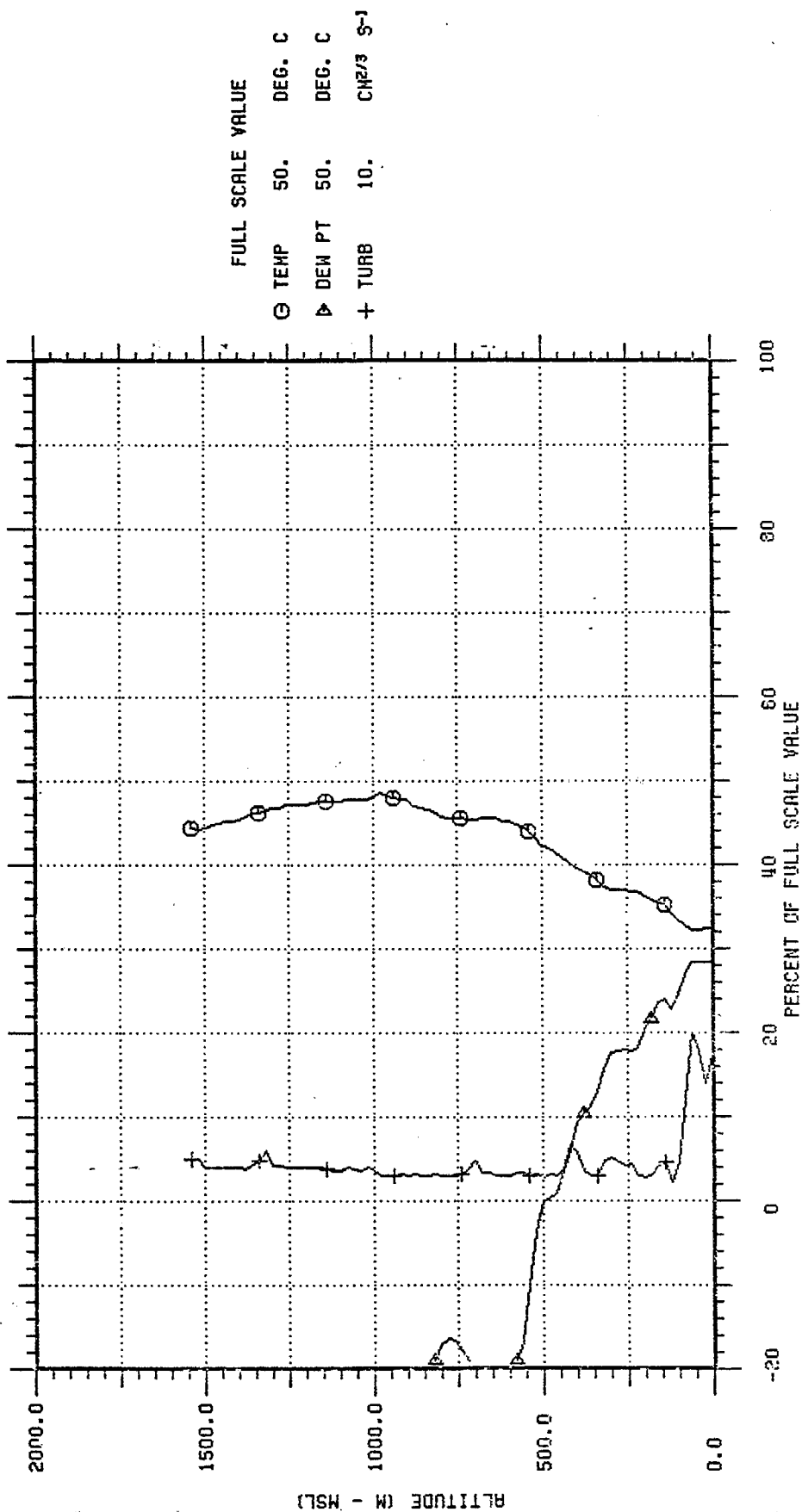
Comparative data using the same measurement technique show comparable mixing layer depths over the water with the exception of the data for Pismo Beach in June which shows much higher depths. Since June characteristically features relatively unstable in the coastal regions, the difference is quite reasonable. It should be noted that these data include test periods when relatively good weather conditions prevailed and are, therefore, not representative of the entire month.

In comparing the NPS data for September 1980 with the data in Table 5.10.1 there is a tendency for the NPS depths to be somewhat higher although the observational days are not necessarily the same. Fig. 5.10.1 shows a sounding for September 28 which very nearly coincides with the NPS radiosonde observation for that date. The NPS technique for determining mixing height keyed primarily on moisture profiles with a secondary emphasis on temperature structure. The mixing height designated by NPS is associated with breaks in the moisture and temperature profiles which are indicated as 260 m (msl) for NPS and 300 m in the aircraft sounding (see Fig. 5.10.1). There is, however, a sharp turbulence top at a little over 100 m as shown in the figure. This is associated with the first temperature inversion rather than the second (300 m). Given the observed turbulence profile it is difficult to envision active mixing in the surface layers above the lowest 100-150 m. This is supported by the air quality data obtained in the same sounding and shown in Fig. 5.10.2. NO, NO_x, and O₃ all show evidence of a low-level mixed layer topped at 100-200 m. The air quality profiles do not support the moisture indications of a mixed layer to 300 m. It is evident that the moisture profile must have originated upstream or have been the result of much slower mixing processes.

The mixing data given by the NPS radiosonde observations are, therefore, taken to be upper limits to the mixing process. Particularly in cases of steep temperature inversions over the winter (e.g., September 28) the effective mixing layer may be somewhat lower than indicated by the radiosonde data.

SANBOX STUDY SPIRAL AT POINT 6

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TIME: 1410 TO 1422 (PDT)



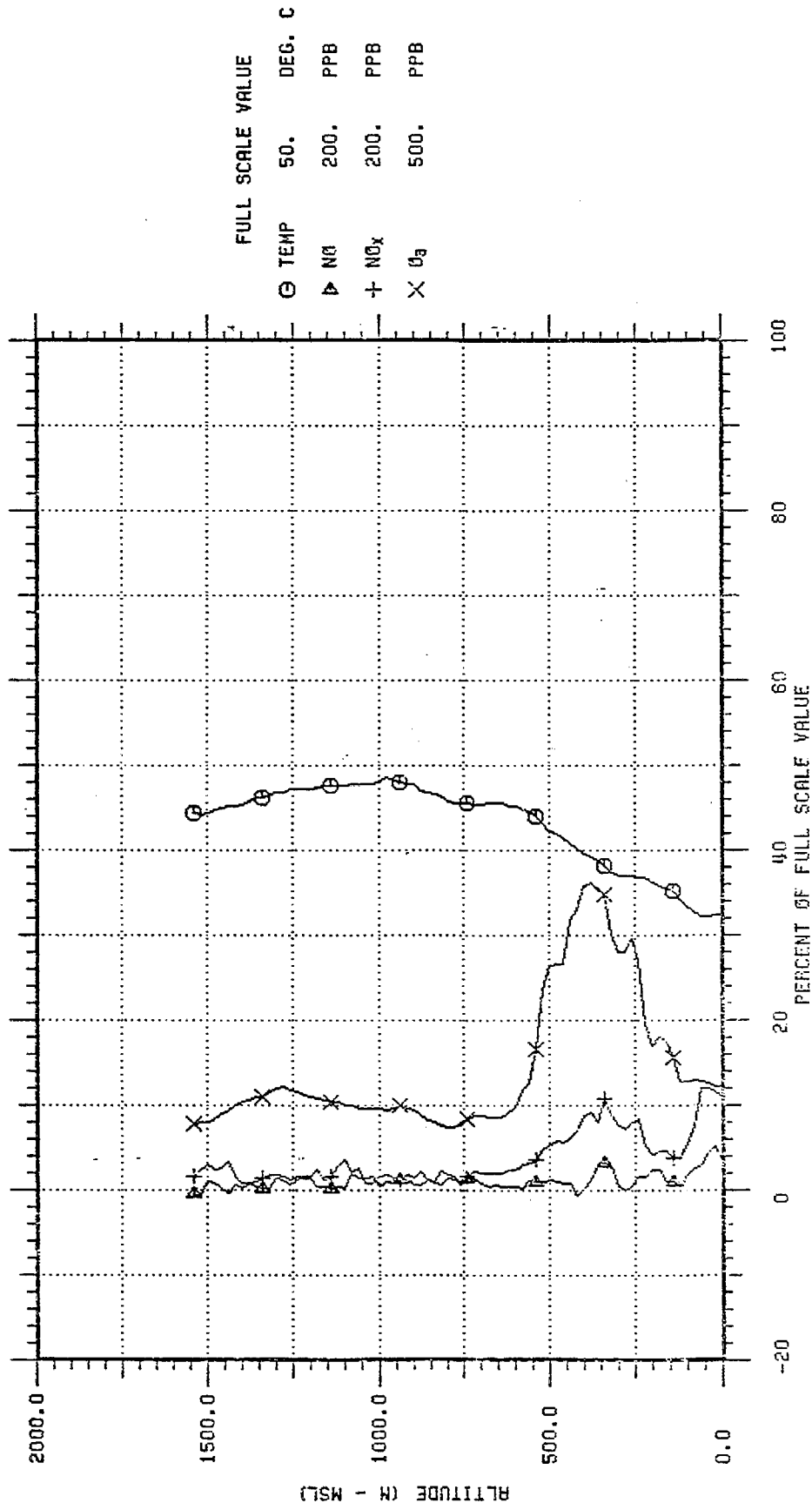
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Fig. 5.10.1 AIRCRAFT SOUNDING NEAR PLATFORM GRACE
(1410 PDT) - September 28, 1980

SANBOX STUDY

SPIRAL AT POINT 6

TAPE/PASS: 184/5 DATE: 9 /28/80
TIME: 1410 TO 1422 (PDT)



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Fig. 5.10.2 AIR QUALITY SOUNDING NEAR PLATFORM GRACE
(1410 PDT) - September 28, 1980

5.11 Effect of Meandering on Dispersion

Dispersion conditions in a light wind environment are frequently influenced strongly by a "meandering" component superimposed on the normal turbulent diffusion effects. Under stronger wind conditions the wind flow direction can often be considered nearly constant over periods of an hour or more. As the wind velocity decreases, the direction tends to shift in a random, low frequency manner which contributes significantly to the initial dilution from the release point.

The wind data from Platform Grace provides an unusual opportunity to examine the magnitude of this meandering in an over-water environment. Wind data from Platform Grace were available for the period August 28 to October 17, 1980. Wind speeds were recorded at two locations on the platform, one on the southeast corner and one on the northwest. Directions were determined only from the northwest unit. Wind directions and speeds were recorded as 10-minute average values. These data permit the direction variance to be evaluated within a one-hour interval.

Data were chosen for assessment when both wind speeds were less than 3 knots for six consecutive 10-minute periods. There were 70 such hours in the 51-day sample. The range of wind directions within each consecutive set of six data points was used to evaluate the variance for the hour.

The median range for the hourly variations in direction was 92° . Ten percent of the hours had ranges of 34° or less. The latter is equivalent to a standard deviation of about 8° . For comparison, at a distance of 10 km the cloud width for an E-category plume (y) corresponds to an angular spread of 2.5° . The total spread of the cloud (with meandering) over a one-hour period would then be considered as the sum of the variances of the two components or about 8.4° .

It can be seen, therefore, that the contribution of the meandering component is very substantial even under minimum conditions.

6.0

CONCLUSIONS AND RECOMMENDATIONS

1. The wind flow patterns in the Ventura/Santa Barbara area are among the most complex of any air basin in California. During the summer, terrain and stability forces interact to control the flow patterns in a diurnally changing, dynamic manner.
2. Air parcels and pollutants readily ventilate out of the channel area as long as stability forces do not restrict the flow up the terrain slopes and out of the basin. This ventilation happens generally in the afternoon when the slopes are heated and at other times of day when deep, mixing layers are present. During periods of warm temperatures aloft, transport inland from the coast effectively stops with the cessation of the seabreeze (usually about 19 PDT during the summer). Under these conditions the only exit for air parcels over the channel is offshore, southward along the coast.
3. Under conditions of offshore pressure gradients (higher pressure inland) an easterly flow occurs at night along the coast from Carpinteria to Pt. Conception. A southeasterly flow is frequently present at night offshore of the Ventura coast. These east and southeast winds are replaced, at least briefly, in the channel during the afternoon by westerly winds. Pollutants in the channel are carried eastward during the afternoon and if they do not escape up the slopes may be returned to the channel during the night by easterly pressure gradient and/or drainage winds.
4. Under episode conditions, with warm temperatures aloft and offshore pressure gradients, this diurnal reversal of flow may result in the creation of a "reservoir" of pollutants offshore which do not escape from the basin during the normal diurnal cycle.
5. Even under normal summer conditions the offshore channel area is subjected to marked, diurnal changes in wind direction as the seabreeze, upslope flow and the nocturnal drainage and stability forces exert more or less influence.
6. Timing of the maximum ozone concentrations in the area does not vary greatly from the coast to inland valleys. This raises questions about the possible influence of local or near-upwind sources on ozone concentrations in the inland valleys.
7. There is evidence of a shallow marine layer moving into the inland valleys from the coast in mid-afternoon. This layer forms by contact with the cool ocean surface and is then transported inland. In spite of surface heating effects, the layer frequently maintains its integrity as far as Piru and Simi. The result of the cool, undercutting marine layer

is to provide a shallow mixing depth in which pollutants cannot be diluted rapidly by vertical mixing. It has been noted that the highest ozone concentrations in the inland valleys often occur within this marine layer and not in the well-mixed air ahead of this marine layer.

8. The background ozone concentrations moving into the area were observed by aircraft soundings. The background varied during the field program from 2-3 pphm to 7-8 pphm. This type of variation clearly affects the occurrence of ozone exceedances.
9. Fumigation of elevated pollutants moving onshore was illustrated on October 2 by a series of soundings offshore and inland. Although the elevated pollutants were not mixed to the surface at the immediate coast at Ventura, they reached the surface well before reaching Santa Paula.
10. Most of the tracer trajectories were subjected to marked wind shifts due to the dynamic nature of the wind flow patterns in the channel. Tests 1 and 4 were exceptions in that steady, organized flow existed long enough for the tracer material to reach the coast.
11. The timing and trajectories of some of the tracer tests resulted in material arriving at the coast after the sea-breeze had terminated. In these cases, there was no effective mechanism for transporting the tracer material into the inland valleys.
12. Comparison of maximum tracer concentrations with Pasquill stability categories indicates that concentrations corresponded to E to G categories under conditions of direct impact. In the cases where light winds, wind shifts and/or transport into the inland valleys occurred, the maximum concentrations corresponded to lower stability categories (typically D). The influence of wind shifts, which occur frequently in the channel, is to cause much more rapid tracer dilution than would otherwise occur.
13. Cloud width measurements from the tracer data also correspond primarily to E to F categories when direct impact of the tracer plume was involved.
14. An examination was made of background tracer concentrations in the area, particularly in view of BLM tests being conducted during the period. The background SF_6 concentrations were generally less than 10 ppt but values as high as 30-50 ppt were found in the last half of the program. These concentrations are small in comparison to the maximum test concentrations observed and do not appreciably affect the test results.

15. There was evidence of an ozone buildup as an offshore "reservoir" during the episode conditions from September 29 to October 5. This buildup was largely manifested as a high background at Pt. Conception and Platform Grace.
16. Ozone concentrations at South Mt. (elevation 2260 ft. msl) showed high values during the late part of the episode period. In a 60-hour period from October 3-5 there were only 3 hours with ozone concentrations at South Mt. of 10 pphm or less. The source of this ozone aloft is believed to be the terrain slopes on the east side of the basin. Ozone is pumped upward by the slopes and may be transported westward by easterly winds. Thereafter, it is subject to the dynamically changing wind environment offshore. Since this ozone may be in air layers which are not connected to the surface, the opportunities for NO_x reduction are limited and the lifetime of the ozone may be relatively long until ventilated out of the basin.
17. Calculated air and ozone fluxes reflected the importance of the seabreeze flow in ventilating the channel area. Unusually high flux rates on October 1 represent the effects of very warm inland temperatures and the resulting, deep mixing layers.
18. Indications exist of rather frequent pulses of ozone being observed in the early evening, along the Ventura coast. These pulses arrive in conjunction with a seabreeze flow from the west or southwest. A striking example on October 2 resulted in 13 pphm of ozone at Port Hueneme, at 20-21 PST, accompanied by a dense fog. An analysis of the trajectory for this parcel suggests transport offshore from the southwest, possibly originating in the South Coast Air Basin.
19. Elevated layers of ozone were observed over the Simi Hills imbedded in a southeasterly wind layer and presumably being transported from the San Fernando Valley. No influence of these layers on surface concentrations was observed and no mechanism has been offered for transporting the ozone to surface levels in the South Central Coast Basin.
20. Comparison of Naval Post-Graduate School mixing height data with aircraft sounding data over the water suggests that the NPS data may represent an upper limit to the height of the mixing layer. The effective mixing layer may be somewhat lower, on occasion.
21. Definition and predictability of the wind field in the channel contributes the major problem in modeling the air quality environment. Additional wind measurements in the channel will be needed for a better understanding of the patterns.

22. The problem of transport of ozone or precursors from the South Coast Air Basin into the South Central Coast Basin needs additional work. Tracer studies are suggested with the aim of identifying the ultimate fate and contribution of elevated layers over the Simi Hills as well as possible contributions along the offshore route.
23. An important result of the study is the occurrence of ozone layers aloft over the Ventura coastal area. These were observed not only at South Mt. but on frequent aircraft flights. Their fate and contribution to surface ozone concentrations needs further study.
24. Widespread carry-over of small tracer concentrations was observed in the coastal area on most days following the day of the release. If this carry-over is related to the potential carry-over of ozone from one day to the next, the carry-over might amount to 1-2 pphm ozone contribution on the following day, at the most. This does not include the carry-over contribution of ozone layers aloft which may be considerably more important.

7. REFERENCES

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